ASSESSMENT

Potential for Using Woody Biomass for Heat and/or Power in Utah's Institutions and Industries

December 2006

Prepared by

Laura L. Lowe

Division of Forestry, Fire and State Lands

Utah Department of Natural Resources

WESTERN GOVERNORS' ASSOCIATION

The preparation of this report was financed in part by funds provided by the Western Governors' Association, the USDA Forest Service, and the Utah Division of Forestry, Fire & State Lands.

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Disclaimers

This study focuses on larger automated biomass boiler systems rather than on small, hand-fed boilers or furnaces. The analyses presented in this report are based on assumed representative characteristecs and conditions of a "typical" boiler facility. However, every facility is unique and may or may not be represented by the information presented. This information is not intended to be used to make investment decisions, but to describe the biomass boiler potential in Utah. The markets related to energy, construction, and biomass boilers are currently very dynamic, and conditions represented in this assessement are likely to change. The biomass boiler market, particularly relating to smaller systems, is still developing in the United States; therefore, the characteristics and conclusions presented herein are likely to change within the next several years.

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EXECUTIVE SUMMARY

The USDA Forest Service (USFS) *Fuels for Schools and Beyond* program is designed to promote forest health, facilitate the removal of excess fuels from our forests, and provide a source of renewable energy by assisting in the development and promotion of economically viable heating systems that use woody biomass for fuel in public and private buildings. The USFS is now expanding beyond the demonstration phase of the program and moving the concept towards commercialization.

The purpose of this study is to assess the potential opportunities and challenges presented by introducing new, or converting existing boilers in the state of Utah to, wood-fueled boilers. This report is based on initial analysis for the Fuels for Schools and Beyond program, but to give the reader more background on the environment in which the program will operate in Utah, it expanded to include further analysis of supply, the industry, additional woody biomass energy uses, and other opportunities and barriers. The potential benefits of using woody biomass as a fuel source include the following:

- create productive local outlets for wood generated from forest thinning operations
- help support fire hazard/fuel reduction programs
- help stabilize the forest products industry
- enable long-term fuel cost stabilization and savings for boiler owners
- provide (thermal) energy independence which contributes to economic and national security
- develop a local, renewable fuel resource
- reduce local and regional pollution caused by forest fires and open burning of forest residues
- reduce greenhouse gas emissions associated with the disposal of biomass and replacement of fossil fuels
- restore forests to sustainable, healthy conditions
- provide rural employment and economic development opportunities
- increase local, state, and federal tax revenue through increased employment and economic development
- promote watershed health and productivity
- reduce cost of fire suppression and damage

The first part of this study reviews the woody biomass potential in the state. One-third of the state's land is deemed forest land, growing trees that capture solar energy during photosynthesis. Utah's forests are capable of sustainably producing large amounts of wood for products and energy.

Next comes a review of Utah's wood products industry. Products and services offered are discussed as well as county of location. Capacity and utilization are covered including the production and disposition of mill residues.

The third part of the study analyzes the limited information available in the State's boiler certificate database to determine the potential commercial opportunities and challenges in converting or replacing a significant number of Utah's 12,308 existing boilers with wood-fueled boilers. Findings include:

- 62% of boilers in the database are less than 1,000,000 BTU/hr in size. Boilers of such small size are currently not likely candidates for conversion.
- 95% list "Gas" as their existing fuel source.
- 73% were installed within the past 20 years, 20% are 20 to 39 years old, 5% are 40 to 59 years old, and 1% are at least 60 years old.
- 59% of the boilers were deemed to be privately owned facilities or their facility type was unknown, but 19% are K-12 schools; 7% are government buildings; 4% are health-related facilities; and 3% were higher education.
- 35% of the boilers are used for water heating, 13% for steam heating, 31% for hot water supply, 20% for process water, and <1% for power.

The fourth part of the study uses information from the State's boiler database to estimate the potential size and scope of a wood-fired boiler market in Utah, based solely on calculations of simple payback through annual fuel savings on a boiler conversion investment.[a] Project costs and impact of changing fuel costs are discussed. Two scenarios were developed to differentiate between payback periods: (1) when boiler replacement is likely necessary and (2) when it is not.

The primary observations of the analysis (based on the underlying assumptions discussed in the report) are as follows:

- There appear to be 103 boilers with payback periods less than 10 years when boiler replacement is not required (160 had paybacks between 10 and 15 years). Of these boilers, existing fuel sources include gas, electricity, oil, and propane, but all are larger than 3,000,000 BTU/hr size.

- There appear to be 499 boilers with payback periods less than 15 years when boiler replacement is required. Analysis of this group of boilers indicates that 3 are over 60 years old, and total of 178 are at least 30 years old; these ages suggest replacement may be needed in the relatively near future.

Beyond the concept of retrofitting facilities that currently use some form of fossil fuel, this study also looks at the potential for new construction installations. Projections for population growth and increased school construction are discussed, as are the possibilities of district heat, combined heat and power, biofuels, and co-firing.

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[a] The simple payback calculations were based upon a number of broad assumptions outlined in the report and have limited benefit beyond showing the estimated time for annual fuel savings to pay for initial capital and project costs. Facilities considering installation of a biomass system need to have a detailed feasibility assessment done by a qualified engineer. The Fuels for Schools and Beyond program currently has a contract with CTA Architects and Engineers to perform a pre-feasibility assessment for schools and other public buildings in the region. Private entities are encouraged to contract for similar assessment work.

Using the past 10 years as a predictor of the future, analysis suggests that about 90 boilers will be installed each year that would be viable as biomass systems. If each of those 90 boilers installed each year were fueled by woody biomass, that would translate to a new wood demand of about 80,289 tons of wood per year, which could be generated from thinning approximately 8,000 acres per year, based on 10 tons of excess biomass per acre.

There are many additional issues that need to be considered. Some of the issues identified by this study and discussed in brief include: government programs and drivers, economic development and a service infrastructure, feedstock issues, environmental and political issues, air quality issues, acceptance of renewable energy forms, and facility-specific issues.

Boiler conversions are more likely for the following situations:

- Facilities with a high demand for fuel for heating, cooling, domestic hot water and/or power.
- Facilities located near other biomass boiler systems.
- Facilities located near wood waste producers (for example: log home builders, post and pole mills, and other mills).
- Facilities that have significant forested acres under their control.
- Facilities located in areas without access to natural gas.
- Facilities located in rural areas.
- Facilities that could burn pellets.
- Facilities that could utilize urban tree waste and/or clean construction waste.
- Facilities willing to lead the market and be a demonstration site.

Boiler conversions are less likely for the following situations:

- Facilities with intermittent heating demands and high peak loads.
- Current boiler output less than 1 MMBtu/hour.
- Fuel use of less than 1,000 MMBtu/year.
- Existing annual fuel bill less than $20,000.
- Facilities with electric base board heat or numerous heat sources.
- Facilities lacking access to the boiler room.
- Facilities requiring significant buried pipe between biomass boiler building and existing system.
- Facilities with energy efficient building envelopes that consume very little heat energy.
- Facilities with significant space constraints.

This study concludes by indicating the need to pursue several activities to further efforts towards commercialization of the Fuels for Schools concept:

- Engage key stakeholders in next steps
- Continue to address biomass supply issues

- Explore additional partnerships, drivers, and opportunities
- Disseminate information
- Construct a demonstration project in Utah

The Appendix includes tables and figures used in the initial identification of boiler conversion candidates, the assumptions used in the payback calculations, and boilers within selected payback ranges.

This report identifies opportunities to use forest biomass, a renewable and recyclable resource, to help improve the health of our forests while at the same time reducing the high energy costs of schools and other public buildings. Funding opportunities for facility construction may also be emerging from USDA Rural Development grant and loan programs, the Energy Policy Act of 2005, and other sources. The largest remaining obstacle is the guarantee of a reliable biomass supply over the payback period, especially from the high proportion of Utah's forests that are managed by federal agencies.

INTRODUCTION

Background

After decades of fire suppression efforts and decreased harvesting on public lands, many forests have become overstocked with undergrowth and dead trees as the plants compete for limited water and nutrients. This has contributed to declining forest health and, along with the drought, has left the forests susceptible to insect infestation, disease, invasive species, and catastrophic wildfire. The accumulation of fuel acts as a ladder to take a fire up to the forest canopy where it is difficult to control. In the past decade there have been terrible fires that burned millions of acres, hundreds of homes, cost millions of dollars to fight, led to deaths, and greatly impacted air quality, watersheds, wildlife habitat and ecosystems, erosion, recreation, and other forest values. Also, more people are building homes in forested areas known as the wildland-urban interface, adding to the potential loss of life and property from fire. As a consequence of these catastrophic wildfires, there has been a forest management shift to reduce fuels, improve the health of forests, and find ways to better utilize woody biomass.

There are two problems that need to be solved together to remove a major obstacle for the use of woody biomass for energy. Before an infrastructure for delivery of biomass will be developed, a viable market that will pay an adequate price for the resource must be established within a feasible transportation distance. And, at the same time, those who invest in biomass-fueled systems need to be assured that there will be a reliable fuel source delivered at competitive prices over a long enough time period to assure payback of their large capital investments.

Although Utahns have been blessed with a number of regional resources that have helped keep our energy prices some of the lowest in the nation, we have not been immune to volatility in the energy market. Political, social, and economic unrest in the world coupled with increasing demand for limited fossil fuels have taken their toll on our energy budgets. There needs to be a way to bring energy policy and land management together to solve some of the problems associated with these two areas of interest.

The USDA Forest Service (USFS) is interested in facilitating the removal of excess fuels from our forests by assisting in the development of viable commercial uses of removed woody materials. The Fuels for Schools program is in the demonstration phase of a 3-phase USFS initiative to promote and encourage the use of wood biomass as a renewable, natural resource to provide a clean, readily available energy source suitable for use in heating systems in public and private buildings.

The Fuels for Schools and Beyond program was developed in USDA Forest Service Regions 1 and 4 in response to the aftermath of the Bitterroot Valley Montana Fires of 2000. The community sought a proactive solution to remove the build-up of unmarketable wood in the local forests, which contributed to poor ecosystem health and wildfires, and to lower the heating costs in taxpayer-funded schools. After researching successful wood-fueled systems in other parts of the country, including the biomass system at the University of Idaho that has been in operation for decades, a partnership was formed between the Forest Service and the State Foresters. The initial phase was to develop demonstration projects in each of the states. The Darby Montana school district was selected to be the pilot project in the region. Their biomass system became operational Fall 2003. Their estimated annual fuel savings from using wood chips rather than heating oil is $90,000. The fuel savings allow schools to channel their limited resources back into education. Since Darby, a number of other projects have come on-line or are in the development phase in the region. These include medical centers, universities, and correctional facilities, as well as schools. Because the project list is dynamic, it is not included in this report. However, the reader is invited to learn more about the regional projects from the Fuels for Schools website.[b] One program facility that is scheduled to become operational in January 2007 is the Northern Regional Corrections facility in Carson City, Nevada. Along with providing heat for the facility, biomass will also generate 1 MW of power. Using wood chips rather than natural gas for fuel is expected to generate annual savings of $900,000. Many other states are now getting involved. The next phase of the Forest Service initiative is the expansion of this concept to other schools, institutions, and industries.

Heating with wood is a very old concept. Some countries (e.g. less developed countries on the African continent) still utilize wood for the bulk of their energy. However, open fires, fireplaces, and old wood burning stoves didn't provide complete combustion of the wood, which contributed to air pollution. Heating with fossil fuels such as coal, heating oil, propane, natural gas, and electricity (an energy source typically generated from fossil fuels such as coal) became more prevalent. Over time, wood-fired heating system technology has greatly improved allowing use of this low-cost, locally produced, renewable resource to be used in clean-burning, efficient boilers.

European countries have embraced this form of heating. They have created incentives to use renewable energy and penalties for not using it.[1] There is a growing demand for environmentally friendly energy fuels. This is because the European Union has set targets to reduce greenhouse gas emissions under the Kyoto Accord. As an illustration of the European demand for biomass energy, pellet plants in British Columbia will salvage pine beetle-killed timber to export an anticipated two million tonnes of wood pellets per year to Europe for use in fuel energy plants.[2] Millions of tons of unsalvageable blown down wood from the hurricanes in the southern U.S. were chipped and shipped to Europe for energy use.[3]

The wood products industry has been using wood waste products to produce heat and power for their operations for decades. The idea has worked its way into other applications. Some of the New England states, such as Vermont, have been using wood to heat schools and other buildings for years, and the idea is spreading to other parts of the country.

Purpose

The purpose of this study is to assess the potential opportunities and challenges presented by converting or replacing existing boilers in the state of Utah with wood-fueled boilers. The report

[b] For more information regarding the regional projects (or information about the program in general), visit the Fuels for Schools and Beyond website at www.fuelsforschools.org

describes and identifies the potential candidates for boiler conversion in the state of Utah based on selected criteria, and highlights potential strategies to focus efforts for concept expansion and commercialization. This report is based on initial analysis for the Fuels for Schools and Beyond program, but to give the reader more background on the environment in which the program will operate in Utah, it expanded to include further analysis of supply, the industry, additional woody biomass energy uses, and other opportunities and barriers.

It is important for the reader to recognize the assumptions made in this assessment, especially related to fuel price, are extremely variable and can dramatically alter the economic picture. The marketplace is also changing with new types and sizes of biomass systems becoming available. The dynamic marketplace will also impact the economic picture.

Benefits of Biomass

The Federal Energy Regulatory Commission defines biomass in its broadest sense as "any organic material not derived from fossil fuels." Biomass feedstocks[c] include forest resources, agricultural residues and products, ocean plants, and resources from the municipal waste stream including solid wastes, biosolids, sewage, and waste buried in landfills. The solar energy, which drives photosynthesis, is stored in the chemical and structural components of biomass. When that energy is released biomass can produce heat, electricity, liquid and gaseous fuels, and a variety of useful chemicals, including those currently derived from fossil fuels. Although some of the other feedstocks are listed in the supply section of this report, woody biomass, the largest of the subtypes, is our focus. It is thought that large-scale conversions or replacements of existing boilers to use woody biomass as a fuel source have the potential to:

- create productive local outlets for wood generated from forest thinning operations
- help support fire hazard/fuel reduction programs
- help stabilize the forest products industry
- enable long-term fuel cost stabilization and savings for boiler owners
- provide (thermal) energy independence which contributes to economic and national security
- develop a local, renewable fuel resource
- reduce local and regional pollution caused by forest fires and open burning of forest residues
- reduce greenhouse gas emissions associated with the disposal of biomass
- restore forests to sustainable, healthy conditions
- provide rural employment and economic development opportunities
- increase local, state, and federal tax revenue through increased employment and economic development
- promote watershed health and productivity
- reduce the cost of fire suppression and damage

[c] Feedstock refers to material that is converted to another form or product. In context of this report, it refers to the original form of the biomass such as a tree or shrub prior to its conversion to energy.

Removing unhealthy, damaged, and small diameter wood from the forest through thinning operations can be expensive. Because there have been few if any markets for such wood, removal has typically occurred only if the costs could be offset by removing valuable timber in the process. A common way of disposing of the unwanted tops, limbs, and undesirable portions is to burn the slash pile. There is a new paradigm spreading as entrepreneurs are finding new ways to utilize wood that had traditionally been thought of as unusable and disposed of as waste. Even still, there is an abundant supply of woody biomass that can be put to productive use. Energy production is the lowest-valued use for wood. By ensuring that any fraction of the wood that has a higher valued use is put to that higher use, with the remainder used for energy, some or all of the costs of removal from the forest can be covered.

The use of biomass for energy production does not go without environmental impact, from its removal from the forest to energy conversion. However, these impacts have to be balanced against the avoidance of two things, both of which also impact the environment. First, is the avoidance of impacts from an equal amount of energy generated from fossil fuels. Fossil fuels are non-renewable. Their combustion has been identified as a leading cause of greenhouse gas buildup and global warming. Trees, on the other hand, are carbon neutral. As trees grow they take in carbon dioxide. That same quantity of CO_2 is later released during decay or combustion of that tree, and can be taken in by a tree planted in its place. The carbon can be stored indefinitely if the wood is preserved in the form of secondary wood products such as housing, furniture, etc. Wood is also very low in sulfur, one of the leading contributors to acid rain.

Second, and possibly more quantifiably important, is the avoidance of impacts caused by the alternative disposal of biomass residues. Fossil fuels are generally found subsurface in the earth, where they will remain if not removed for utilization. Biomass, however, is found on the surface, and as a renewable resource, will continue to regenerate. Unlike wind, solar, tides, hydro and geothermal renewable energy sources, where lack of utilization only results in lost opportunities rather than realized costs, the failure to utilize biomass results in some real costs. Some of these include tipping fees at landfills, fire fighting costs and air quality, soil quality, habitat, watershed, recreation, and jobs lost when a catastrophic fire destroys a forest ecosystem.

Sustainable management of forests is key to the long-term use of wood. Sustainability in its broad sense means meeting the needs of the current generation without sacrificing the ability of future generations to meet their needs. When applied to forestry, it combines reforestation, growing, nurturing, and harvesting trees and conserving soil, air, and water quality while maintaining plant and animal diversity in an aesthetically pleasing process.[4]

BIOMASS SUPPLY

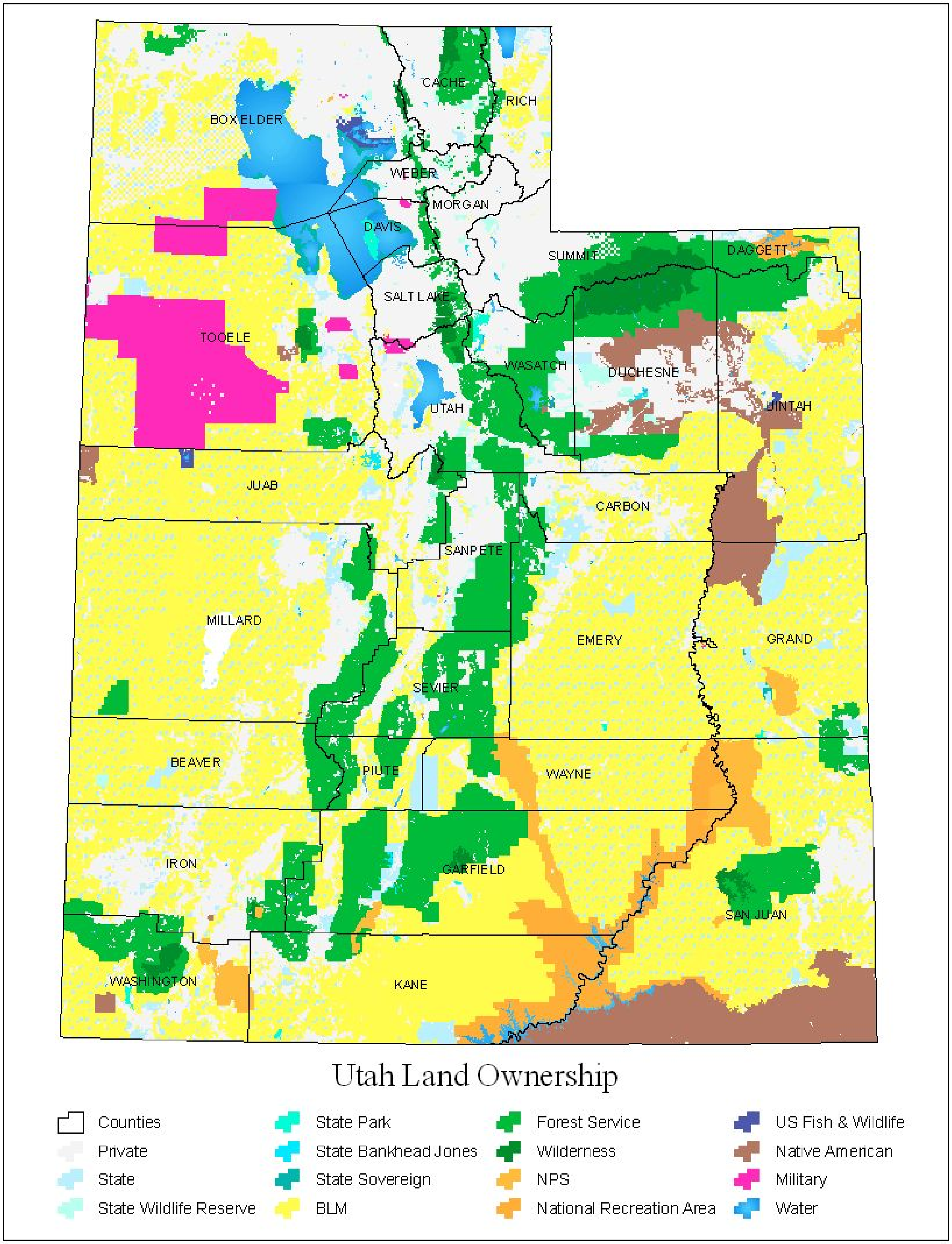
Forests have proven themselves to be one of the nation's most resilient and dependable natural resources. Through the forests, wood was available that was vital to the growth of a civilized nation. It built ships for international trade, homes, factories and stores, and laid the foundation for an expanding railroad system. At the time of European colonization, in 1630, forests covered approximately 1 billion acres or 46% of the land that would become the United States. After converting forestland for agriculture, urbanization, and other purposes, the amount of forest coverage declined to about 1/3 of the nation's land. This conversion took place particularly in the East, which is now enjoying a return of its forests. While it is true that some countries in the world are experiencing deforestation, this is not currently the case in the U.S. The reality is that America has about the same amount of forested area as it did in 1920, despite all of our uses for wood.[5] Over the last several decades, the growth of tree volume has been significantly more than what has been cut or lost to mortality. For example, in Utah, one year's net annual forest growth is about 129 million cubic feet.[6] While only about 8% of this is harvestable annually, forest biomass appears to be steadily increasing, contributing to poor forest health and increasing fuel loads.

Utah is a state of diverse landscapes and ecosystems. There is a great lake of water many times saltier than the ocean, as well as freshwater lakes, the Bonneville salt flats, granite mountains, red sandstone slick rock, deserts, many national parks and monuments, and six national forests. Utah's National Forests are the Ashley, Dixie, Fishlake, Manti-LaSal, Uinta, and Wasatch–Cache. Roughly 30 percent of the land (or 15.7 million acres) in Utah are deemed forest land. This is a higher percentage than the average forest cover of the Rocky Mountain States. The total biomass in live trees in Utah forests is estimated to be over 333 million tons, or in terms of volume, in excess of 15.3 billion cubic feet.[7] This represents the energy equivalent of approximately 200,000,000 MWh of electricity or 29,000,000,000 gallons of gasoline.[d] This is a significant source of potential energy that will continue to be looked toward as other energy costs rise.

Utah's forest land falls under the control of many ownership types. Eastern states have more privately owned forestland, while public lands tend to dominate in the western states. Approximately 75% of Utah's forest land is under federal management (BLM and Forest Service). Figure 1 shows Utah land ownership.

[d] Assuming 40% moisture content. One bone dry ton of fuel will produce 10,000 lbs. of steam to generate 1 megawatt hour of electricity. One MMBtu has the heat equivalent of approximately 8 gallons of gasoline.

Figure 1. Utah Land Ownership



Biomass refers to any plant-derived organic matter.[8] Biomass available for sustainable energy use include woody and herbaceous energy crops, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, and some municipal solid wastes, landfill gasses, and sewage.

Energy crops are harvests developed and grown specifically for energy. The varieties are developed to be fast-growing, drought and pest resistant, and easily harvested. They also provide erosion control and organic matter build-up in soil whose productivity has been reduced over the years. Energy crops include fast growing trees, shrubs, and grasses such as hybrid poplars, hybrid willows, and switchgrass.

Agricultural crop residues are the plant parts, primarily stalks and leaves, left over after removal of the primary food or fiber product. Examples include corn stover (leaves, stalks, cobs, and husks); wheat straw; and rice straw. While agricultural crop residue quantities produced are substantial, only a percentage of them can potentially be collected for bioenergy and bioproduct use, with the rest remaining in the field due to their nutrient adding effect on soil productivity and prevention of soil erosion.

Municipal wastes are considered a renewable energy source when the residential, commercial, and institutional post-consumer wastes contain a significant proportion of plant-derived organic material. Examples are waste paper, cardboard, construction and demolition wood waste, and yard wastes.

Forestry residues include tops, limbs, and other woody material not removed during forest harvesting operations, and woody material resulting from forest management operations such as thinnings and removal of dead and dying trees. Wood processing residues are byproducts that have significant energy potential such as bark, shavings, sawdust, and spent pulping liquors. Woody biomass is the focus of this study as it is used as fuel in biomass boilers. While the other sources of biomass may appear in the following tables, only the woody biomass will be discussed.

There has been a lack of data measuring biomass in the past. However, in recent years a number of studies have tried to rectify that situation. One such national study looked at the feasibility of a billion-ton annual supply.[9] Such national studies presented cumulative data over all or several regions without breakdowns by state. Summaries of some studies that present biomass data of the most relevance to Utah supply are shown in this report. The first, done by the Oak Ridge National Laboratory (ORNL)[10], measured the estimated annual cumulative biomass resources available in dry tons by state and price. The data for Utah is shown in Table 1. For comparison to other states, refer to the ORNL report referenced above.

Table 1. Utah Estimated Annual Cumulative Biomass Resources Available by Price

Delivered Price	<$20/dt	<$30/dt	<$40/dt	<$50/dt
Urban Wastes	138,765	231,275	231,275	231,275
Mill Wastes	20,000	67,000	67,000	102,000
Forest Residue	0	90,000	133,000	173,000
Ag Residues	0	0	216,546	216,546
Switchgrass	0	0	0	0
Short Rotation Woody Crops	0	0	0	0
Total	**158,765**	**388,275**	**647,821**	**722,821**

Delivered price based on $8/ton within a 50-mile distance.
Source: Oak Ridge National Laboratory

The ORNL study grouped forest wood residues into the following categories: logging residues; rough, rotten, and salvable dead wood; excess saplings; and small pole trees. The forest wood residues supplies that could potentially be available for energy use in the U.S. were estimated using a model that first classifies the total forest inventory into the above wood categories (for both softwood and hardwood), and by volume, haul distances, and equipment operability constraints. These numbers were then revised downward to reflect the recoverable quantities taking account of equipment retrieval efficiencies, road access to a site, and the impact of site slope on harvest equipment choice. The costs of obtaining the recoverable forest wood residues were then estimated for each category. Prices include collection, harvesting, chipping, loading, hauling, and unloading costs, a stumpage fee, and a return for profit and risk. Prices are in 1995 dollars. Only logging residues and rough, rotten, and salvable deadwood quantities were included in the figures in the table. Quantities are cumulative at each price (i.e. quantities at $50/dt include all quantities available at lower prices.) Polewood, which represents the growing stock of merchantable trees, was not included in the analysis because it could potentially be left to grow and used for higher value products, so it was doubtful that these trees would be harvested for energy use.

The mill wastes listed above are those residues generated at primary wood mills that produce lumber, pulp, veneers, and other composite wood fiber materials. These include bark; coarse residues (chunks and slabs); and fine residues (shavings and sawdust). Because primary mill residues are concentrated in one source, relatively homogeneous, and clean, nearly 98 percent of such residues are currently used as fuel or to produce other wood fiber products. These residues could be diverted from their current uses if higher prices are offered for their purchase.

As part of its Clean and Diversified Energy Initiative, the Western Governors' Association (WGA) issued a Biomass Task Force Report, which included a Supply Addendum.[11] The data in Table 2 were taken from that report and show the available bone dry tons of biomass each year in Utah.

Table 2. Biomass Resources in Utah, Available Bone Dry Tons/ Year

Source	BDT/Y	Percent of Total Annual Solids
Agriculture	1,625,351	58 %
Forestry	161,592	6 %
Total Biomass in Municipal Wastes	1,003,593	36 %
Total Annual Solids	2,790,535	100 %
	Totals	
Landfilled Municipal Solid Waste Landfill Waste in Place (as is tons)	38,530,470	Landfill gas-to-energy
Waste Water Treatment WWTP Influent (MGD)	218	Biogas from waste-water treatment plants

Source: WGA Biomass Task Force Report, supply addendum

The biomass from forestry in the above table was estimated by looking first at the thinning biomass that could be removed in order to mitigate fire hazard on timberland. The typical definition for Timberland is that it is capable of growing at least 20 cubic feet per acre per year and is not reserved by law or administrative action from timber harvest. It was assumed that half of the treatments on timberland at high risk for stand replacement fire would be even-aged (taking smaller trees first) and half would be uneven-aged (taking trees across all diameter classes) treatments. Only areas that could produce 300 ft^3 (or about 4 ovendry tons) of merchantable wood per acre were considered, assuming that the sales of the merchantable wood (wood used for higher value products such as lumber, pulpwood, posts, and poles) could offset thinning costs. [This assumption drives home the point that thinning is expensive and without a market for the wood, the unmerchantable wood is usually pile burned or left in the woods where it will continue to be potential wild fire fuel.] It was further assumed that half of all the wood removed through treatment would be used for higher value products, with the remaining half available for fuel.

After the above-mentioned filters on timberland, estimates of unused mill residues and forest thinning biomass removals to mitigate fire hazard on other forest land were added. Forest land refers to tree-supporting land other than timber land or reserved forest land. It includes forest land that is incapable of producing 20 ft^3/year of merchantable wood.

The US Forest Service has maintained a database of forest inventories[12] over the years. Mandated by Congress, The Forest Inventory and Analysis (FIA) project's primary objective is to determine the condition, extent, growth, depletions, and volume of timber on the country's forest land. The regional research stations of the USDA Forest Service conduct these inventories. Table 3 shows the most recent inventory data available for Utah.

Table 3. State Forest Inventory Summary Statistics for Utah, 2004

Area of all land (acres, not including census water)	52,511,309
Census water	1,823,577
Acres of forestland (≥120 ft wide and 1 acre in size)	19,596,331
Acres of timberland (non-reserved forestland capable of 20 ft^3/acre/year)	4,192,386
Number of all live trees on forestland (≥1” dbh)	8,515,455,102
Number of all live trees on timberland (≥1” dbh)	2,087,183,229
Number of growing-stock trees on forestland (≥1” dbh)	1,891,301,132
Number of growing-stock trees on timberland (≥1” dbh)	1,581,780,496
Volume of all live trees on forestland (cubic feet) (≥5” dbh)	15,749,094,351
Volume of all live trees on timberland (cubic feet) (≥5” dbh)	7,498,227,523
Volume of all growing stock on forestland (cubic feet) (≥5” dbh)	8,726,639,587
Volume of all growing stock on timberland (cubic feet) (≥5” dbh)	7,250,732,841
Volume of all trees on timberland (board feet) (≥ 9” dbh softwoods, ≥11” dbh hardwoods)	27,781,290,888
Growth of all live trees on forestland (cubic feet)	98,382,492
Growth of growing stock on timberland (cubic feet)	66,790,813
Growth of growing stock on timberland (board feet)	303,938,543
Removals of all live trees on forestland (cubic feet)	-
Removals of growing stock on timberland (cubic feet)	-
Removals of growing stock on timberland (board feet)	-
Mortality of all live trees on forestland (cubic feet)	156,361,671
Mortality of growing stock on timberland (cubic feet)	92,200,750
Mortality of growing stock on timberland (board feet)	408,171,213
All live tree biomass on forestland (dry tons, ≥ 1” dbh)	274,165,009
All live tree biomass on timberland (dry tons, ≥ 1” dbh)	139,084,761
Growing stock merchantable tree biomass on forestland (dry tons, ≥ 5” dbh)	210,193,343
Growing stock merchantable tree biomass on timberland (dry tons, ≥ 5” dbh)	101,353,183

Source: US Forest Service Forest Inventory and Analysis Data Center

In partnership with the Western Forestry Leadership Coalition, the USDA Forest Service research and development issued a report assessing forest biomass and fuel reduction treatments in Western States.[13] The purpose of the study was to measure forest biomass that can potentially be removed as part of the implementation of ecosystem restoration and fuel reduction objectives of the National Fire Plan. The assessment covers forested areas of both private and public ownerships, and describes all standing tree volume including stems, limbs, and tops. Starting with FIA data, potential removal volumes were identified based on a selective removal prescription to reduce a given stand’s density to 30 percent of maximum. Removals generally came from small to mid-sized trees (< 10" dbh). To accommodate old-growth, wildlife habitat, endangered and threatened species, insect outbreaks, watershed protection, and other ecological and multi-resource management objectives, an uneven-aged prescription approach was adopted. The treatable acres were separated into Fire Regime Condition Class (FRCC) measuring how much a forest has departed from natural wildland fire conditions.

Table 4 presents the area statistics for Utah, and Table 5 shows the standing and removal volume for the state.

Table 4. Area Statistics for Utah

Land Area (million acres)	**Total**	52.6
	Forestland	15.7
	Timberland	4.7
Treatment Opportunities (million acres)	**Timberland**	3.6
	Class 2 + 3	1.2
	Class 3	0.1

Class 2 areas need prescribed fire or mechanical treatment to restore ecosystem function
Class 3 areas need mechanical treatment prior to using fire as a restorative tool
Source: USDA Forest Service, RMRS-GTR-149.

Table 5. Standing and Removal Volume, Utah

Total Forest Volume (million bone dry tons)	**All Timberland**	155.8
	Treatable Timberland	144.6
	Class 2 + 3	43.3
	Class 3	4.0
Volume to Remove (million bone dry tons)	**Treatable Timberland**	54.5
	Class 2 + 3	15.6
	Class 3	1.6

Class 2 areas need prescribed fire or mechanical treatment to restore ecosystem function
Class 3 areas need mechanical treatment prior to using fire as a restorative tool
Source: USDA Forest Service, RMRS-GTR-149.

Because transportation costs can reduce heating system fuel cost savings, it is important to have supply within a reasonable proximity to the facilities that will utilize the biomass. The general recommendation is a transport distance of 50 miles or less from source to use, but there is a sensitivity to transportation fuel costs. To get a better idea of geographic supply within the state, Table 6 shows the acres of accessible forest in each county. The forested land generally follows the mountain ranges in the state. The Wasatch Range of the Rockies runs north-south through the state around the I-15 corridor, and the Uintah range runs east-west from the Wasatch front east toward Colorado. Figure 2 shows the forested areas of the state by tree species.

Figure 2. Utah's Forested Areas by Species

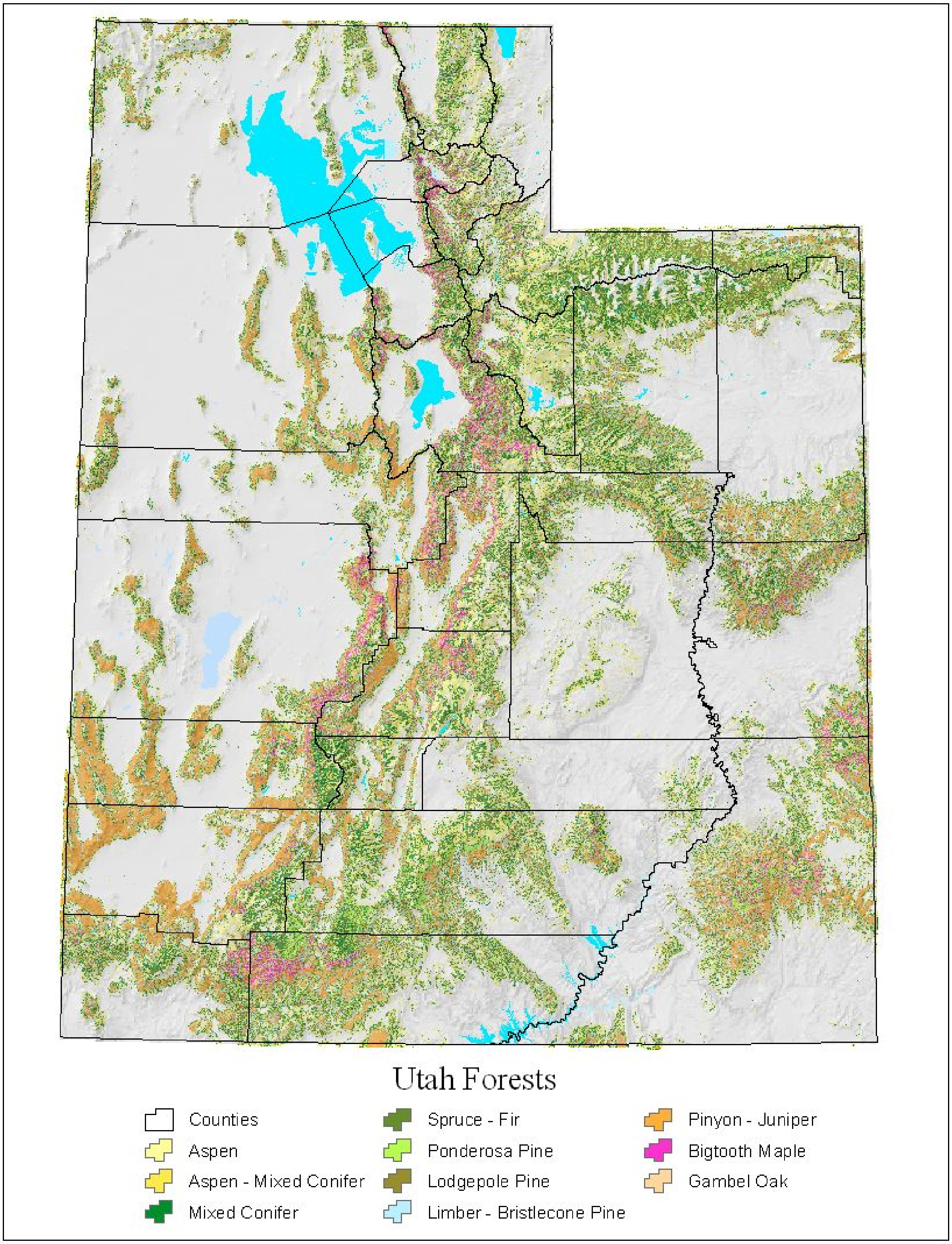


Table 6. Forest Inventory in Utah by County

County	Total Land Class (acres)	Accessible Forest (acres)	Nonforest (acres)
Beaver	1,659,050	820,879	838,171
Box Elder	4,306,563	419,460	3,057,226
Cache	750,761	331,181	416,844
Carbon	950,120	545,011	405,110
Daggett	462,757	339,199	123,558
Davis	405,566	27,038	148,708
Duchesne	2,083,817	1,175,457	895,715
Emery	2,855,396	825,361	2,030,035
Garfield	3,333,256	1,737,082	1,583,044
Grand	2,364,259	1,002,777	1,361,483
Iron	2,113,142	962,576	1,150,566
Juab	2,179,942	542,103	1,637,839
Kane	2,629,410	1,422,721	1,168,593
Millard	4,369,916	768,963	3,589,037
Morgan	390,904	200,118	190,786
Piute	490,083	267,546	222,537
Rich	695,225	83,764	574,849
Salt Lake	516,977	142,358	332,703
San Juan	5,077,042	1,926,805	3,040,547
Sanpete	1,025,683	570,986	454,696
Sevier	1,227,668	729,682	484,969
Summit	1,204,480	770,660	430,343
Tooele	4,663,735	422,150	3,952,703
Uintah	2,879,335	970,539	1,890,712
Utah	1,370,204	740,612	530,119
Wasatch	773,867	516,114	232,169
Washington	1,555,149	834,887	720,262
Wayne	1,578,536	333,981	1,244,555
Weber	422,044	166,324	178,379
Total	**54,334,887**	**19,596,331**	**32,886,258**

(Source: US Forest Service Forest Inventory and Analysis Data Center http://www.ncrs2.fs.fed.us/4801/FIADB/index.htm)

Boilers located in cities closer to forested lands – the source of woody biomass fuel – would typically have lower biomass fuel costs. Proximity to forested lands may also be an indicator of a viable forest products industry that may be able to provide the infrastructure necessary to supply the wood chips or pellet fuel to the facility.

Utah's Coordinated Resource Offering Protocol (CROP) analysis will be released about the same time as this report. There are two CROP analyses areas in Utah. The first is a 100-mile radius circle centered in Manila, Daggett County, Utah. This analysis looked at resources from 3 National Forests, State Lands, 2 State Departments of Transportation, 7 BLM Districts and 20 Counties within Utah, Idaho, Wyoming, and Colorado. The second analysis area is an ellipse 125 miles long (N/S) and 100 miles wide (E/W), centered in Panguitch, Garfield County, Utah. It covers 4 national Forests (11 ranger districts), State Lands, 2 State Departments of Transportation, 10 BLM Districts and 13 Counties within Utah and Arizona. Between the two studies, most of the forested land in Utah has been covered as well as stretching into areas of surrounding states. The difference between the CROP analysis and the forest inventory analysis (FIA) is that FIA shows the wood available on the ground, but CROP seeks to discover where and when the wood will be taken off the ground. The goal is, through a coordination of the various agencies, to provide a levelized supply of wood to the forest products industry in the state.

There is considerable potential biomass supply within the state. However, there are a number of issues that place challenges on its efficient use.

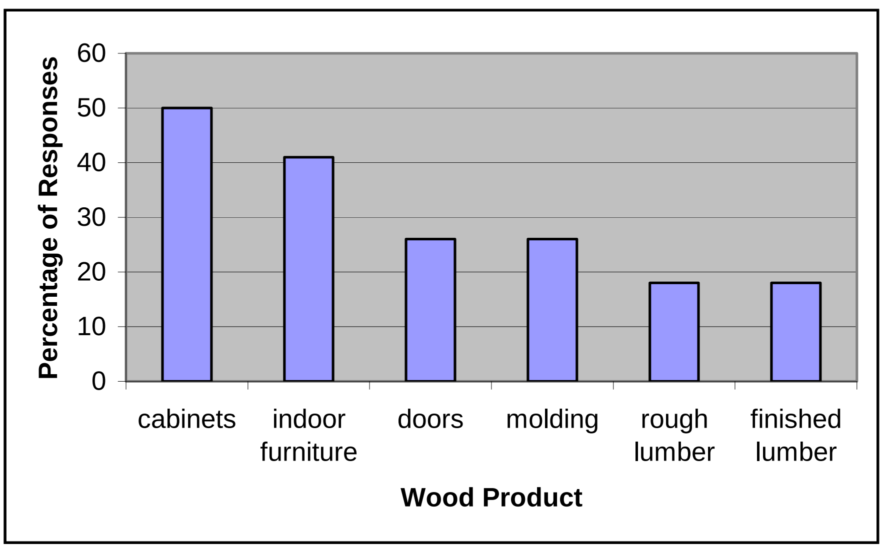
UTAH WOOD PRODUCTS INDUSTRY

The most recent source of information on Utah's Wood Industry is from a survey conducted by Utah State University Extension Forestry.[14] A brief review of the industry follows, based on the information gathered. This survey also produced a directory of industry participants in and near Utah. It can be found on their website at http://extension.usu.edu/forestry/Business/WoodDirectory.htm.

Based on the survey data, the vast majority (81%) of Utah's wood products industry is involved in manufacturing. These consist mainly of cabinet shops, furniture manufacturers, and other custom woodworking businesses. The remaining 19% of the businesses are involved in the sale of wood products, on either the wholesale or retail level.

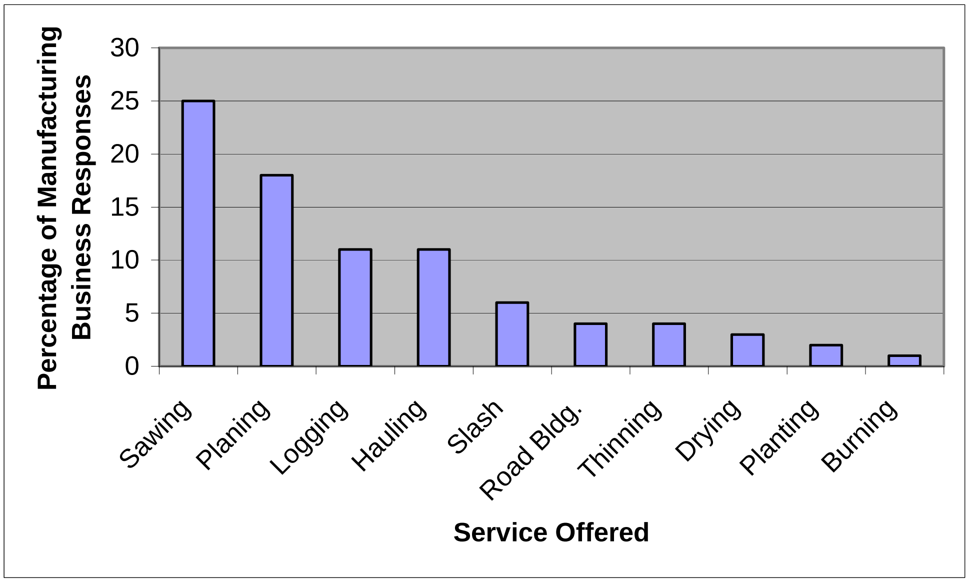
The wood industry in Utah employs over 2,800 full-time and 350 part-time jobs and generates several hundred million dollars in annual sales. The top six wood products manufactured and/or sold by respondents are shown in Figure 3.

Figure 3. Top Six Wood Products Offered by Utah Wood Product Industry



Businesses in Utah's Wood Industry provide a variety of services, the most common being custom sawing, planing and logging services. Figure 4 shows the services offered. Most of the enterprises indicated that they utilize less than 200,000 board feet of wood per year, and nearly a third said they receive their wood from distances over 300 miles away, primarily from wood wholesalers.

Figure 4. Services Provided by Utah Wood Product Manufacturing Businesses



Another study, by University of Montana's Bureau of Business and Economic Research and the Rocky Mountain Research Station of the Forest Service, looked at the forest products industry in each of the Four Corner states.[15] Unlike the USU study, which attempted to look at the entire spectrum of producers in Utah's wood industry, "secondary products" were not included in this second study. The highlights from Utah's section of the report appear in the following paragraphs and tables.

Primary products are those directly manufactured from timber. These include lumber, posts and poles, house logs, log furniture, log beams and rafters, and other specialty products. There are also reconstituted products made from mill residue, generated in the production of primary products, and chipping or grinding timber. Derivative or secondary products are made from primary wood products and include window frames, doors, trusses, pallets, cabinets, and furniture.

Forest Industry Sectors

In 2002 there were 49 active primary forest product industry manufacturers located in 20 Utah counties. The type of product and county of location of facilities is listed in Table 7 with a comparison from 10 years previous.

Utah's forest industry has experienced changes over the past 20 years similar to those experienced across the Western states. The number of sawmills decreased while the number and diversity of other manufacturers increased. Utah's sawmill sector has seen several decades of decline. The production loss was mostly accounted by the mills that produced over 1 MMBF of lumber annually. Lumber production decreased 58% in the decade of 1992 to 2002. Table 8 compares sawmill production size class across three time frames.

While the number of producers decreased, sales of primary wood products experienced a slight increase between 1992 and 2002. The increased sales figures were due to increased sales of log homes and other products. Utah's log home sector is the fourth largest in the Western U.S. trailing Montana, Idaho, and Colorado. During that decade there was also significant expansion of facilities producing other primary wood products such as log furniture, posts and poles, and decorative bark.

Table 7. Utah Primary Wood Product Facilities by County and Product, 2002 and 1992.

COUNTY	LUMBER	LOG HOMES AND HOUSE LOGS	LOG FURNITURE AND OTHER PRODUCTS*	TOTAL
Beaver	1		1	2
Cache	3		1	4
Davis	1			1
Duchesne	2	2		4
Emery	1			1
Garfield	1	1	1	3
Iron	1		1	2
Millard			1	1
Morgan	1			1
Piute			1	1
Salt Lake	1	1	2	4
San Juan	1			1
Sanpete		1	1	2
Sevier	1			1
Summit	3	1		4
Uintah	1	4	1	6
Utah			2	2
Wasatch	2	2		4
Wayne	2	1		3
Weber	1	1		2
2002 Total	**23**	**14**	**12**	**49**
1992 Total	*34*	*13*	*4*	*51*

*Other products include posts, poles, and bark products.

Table 8. Utah Sawmills by Production Size Class, 1966, 1992, and 2002.

YEAR	Under 1 MMBF	Over 1 MMBF	TOTAL	AVERAGE PRODUCTION PER MILL
	Number of Sawmills			MMBF
2002	17	6	23	1.2
1992	25	9	34	1.9
1966	37	13	50	1.4
	Percentage of Lumber Output		Volume (MBF)	
2002	13	87	26,524	
1992	13	87	63,637	
1966	10	90	72,000	

Size class based on reported lumber production
MMBF = million board feet lumber tally
MBF = thousand board feet lumber tally

Capacity and Utilization

Production capacity was defined as the amount of finished product that could be produced given sufficient supplies of raw materials and firm market demand for the product, considering normal maintenance and down time. Utah's annual sawmill production capacity was estimated to be 77.5 MMBF of lumber in 2002. However, only 34 percent of that production capacity was utilized. This was a historically low level of production capacity utilization in Utah as well being below its four-corner neighbor states. Timber processing capacity utilization was about 42 percent across all sectors, not just sawmills. Even this relatively low level of utilization generates significant amount of woody residue that could potentially be used as biomass fuel. And it is probable that many in the wood industry have the capacity to easily add being a supplier of woody biomass fuel to their business portfolios.

Table 9 shows the production and disposition of mill residues in the state. Nearly 90% of all mill residues are currently being utilized. Still there are thousands of tons of residue that go unused each year that could be used as fuel. It is unknown at what price the various utilized residues are being sold. To attract more residues for energy uses would require at least matching the prices received from these current uses.

Table 9. Production and Disposition of Utah Mill Residues, 2002.

RESIDUE TYPE	TOTAL UTILIZED	*Pulp And Board*	*Energy*	*Mulch/ Bedding*	*Unspecified Use*	UNUSED	TOTAL PRODUCED
	-----------Bone Dry Units----------						
Coarse	16,501	-	3,082	-	13,419	2,691	**19,182**
Fine	8,387	-	2	6,378	2,007	43	**8,430**
Sawdust	5,639	-	2	5,179	458	43	**5,682**
Planer Shavings	2,748	-	-	1,199	1,549	-	**2,748**
Bark	5,670	300	1,281	953	3,136	963	**6,633**
TOTAL	*30,558*	*300*	*4,365*	*7,331*	*18,562*	*3,697*	***34,255***
	----------Percentage of Residue Type----------						
Coarse	86.0	-	16.1	-	69.9	14.0	**56.3**
Fine	99.5	-	-	75.7	23.8	0.5	**24.6**
Sawdust	99.2	-	-	91.1	8.1	0.8	**16.6**
Planer Shavings	100.0	-	-	43.6	56.4	-	**8.0**
Bark	85.5	4.5	19.3	14.4	47.3	14.5	**19.4**
TOTAL	***89.2***	*0.9*	*12.7*	*21.4*	*54.2*	***10.8***	***100***

Bone-dry unit = 2,400 lbs of oven-dry wood

BOILERS IN UTAH

Boiler Database

The Utah Labor Commission maintains a database of certificates required for boilers installed in the state, which as of March 2005 includes listings for 12,308 active boiler certificates. The database includes the following information for each active boiler certificate:

- Boiler size
- Current fuel source
- Year of manufacture
- Boiler use
- Boiler location
- Owner
- Other descriptive data

The information available in the boiler database was sorted and summarized in various ways to help describe the characteristics of existing boilers operating in the state, and then get a better sense of the potential for using woody biomass in institutions and industries. It should be noted that the database does not provide complete or logical information for all boilers listed, and some of the boilers listed may be inactive. For the purposes of this study, data were used that were available and logical for each parameter analyzed, ignoring boilers when data were unusable. For this reason, numbers may not always add up between tables. Below are summaries of information for boiler size, current fuel source, age of boiler, facility type, use, and boiler location.

Boiler Size

The database lists boiler size in units of BTU. For the purposes of this study, it was assumed that the boiler sizes listed represent installed boiler output in actual units of BTU per hour. It was also assumed that the listed boiler size was a representative indicator of the annual fuel use. Table 10 presents the number of boilers listed in the database within selected size ranges.

Table 10. Number Of Boilers Listed For Selected Size Ranges

BOILER SIZE RANGE (BTU/hr)	NUMBER OF BOILERS	PERCENT OF TOTAL
<= 500,000	5,141	42 %
500,001 – 1,000,000	2,452	20 %
1,000,001 – 10,000,000	4,284	35 %
10,000,001 – 20,000,000	217	2 %
20,000,001 – 50,000,000	140	1 %
>50,000,000	73	<1 %

Table 10 shows that more than half of boilers in the state (62%) are less than 1,000,000 BTU/hr in size. Boilers of that small size are not likely candidates for conversion to biomass because the annual fuel savings might not be large enough to cover the costs of conversion in a timely manner.

The largest boilers listed in the database are used for the production of electricity. Table 11 lists selected information for the ten largest boilers in the state.

Table 11. The Ten Largest Boilers In The State

SIZE (BTU/hr)	FACILITY	FUEL	MAN YEAR	USE	CITY
6,600,000,000	Intermountain Power Project	Coal	1983	Power	Delta
6,600,000,000	Intermountain Power Project	Coal	1983	Power	Delta
3,341,000,000	Pacificorp	Coal	1983	Process	Castle Dale
3,318,000,000	Pacificorp	Coal	1978	Process	Castle Dale
3,318,000,000	Pacificorp	Coal	1976	Process	Castle Dale
3,300,000,000	Deseret Generation and Transmission	Coal	1984	Power	Bonanza
3,300,000,000	Pacificorp	Coal	1972	Process	Huntington
3,300,000,000	Pacificorp	Coal	1975	Process	Huntington
840,000,000	Pacificorp	Gas	1954	Power	Salt Lake City
765,000,000	Pacificorp	Coal	1956	Process	Helper

Small boiler systems can often be replaced or displaced with small wood chip or pellet fuels systems with low capital costs. Large systems have greater capital costs, but also may have greater annual demand for fuel. The boiler size listed in the database may or may not be a good indicator of actual BTU demand or boiler usage. Experience suggests that boiler size is not a direct indicator of potential project viability. Actual fuel usage is a much better indicator, and those boilers with larger fuel demands will cover the upfront capital costs with annual fuel savings more quickly. Because the price of coal is similar to wood chips on a per ton basis in Utah but coal has a higher Btu content per ton, it is unlikely that biomass boilers will replace coal boilers based solely on economics. However, wood is renewable and releases fewer emissions than coal so various utilities across the country are mixing a portion of biomass with coal to produce electricity. The market for “green tags” is also emerging which could provide additional incentives to use renewable resources. Both of these are discussed further in a later section.

Current Fuel Source

The boiler database lists the current fuel source used to power each boiler. The fuel sources listed are gas, oil, propane, coal, electric, waste heat, and other. Table 12 presents the number of boilers listed in the database for each fuel type available.

Table 12. Number Of Boilers Listed For Each Available Existing Fuel Type

EXISTING FUEL	NUMBER OF BOILERS	PERCENT OF TOTAL
Gas	11,652	95 %
Electric	356	3 %
Coal	118	1 %
Propane	78	<1 %
Oil	68	<1 %
Waste Heat	23	<0.1 %
Other	17	<0.1 %

The vast majority (95%) of the 12,308 boilers in the database list "Gas" as the existing fuel source. Electric boilers are less than 3% of the total and the other fuel sources are less than 1% each.

In order for a boiler conversion project to be viable, the existing fuel source should cost more than the potential biomass fuel cost. Estimated current (delivered) costs for existing fuel sources are presented below.

- Electric: $21/ million BTU[e]
- Fuel Oil: $16/ million BTU
- Propane $17/ million BTU
- Natural Gas: $10/ million BTU
- Coal: $2/ million BTU

These costs can be compared to the estimated biomass fuel costs presented below:

- Wood Chips: $4/ million BTU (based on $40/green ton)
- Wood Pellets: $8/ million BTU

It is interesting to note that even if the price of wood chips were to double, the price per million Btu would still be less than the current cost estimate for natural gas.

The fuel cost estimates suggest that electric boilers would make strong candidates for conversion. The ten largest electric boilers are presented in Table 10. Table 14 presents a list of the ten oldest electric boilers in the state. Older boilers are more likely to be scheduled for replacement.

[e] 1 million BTU = 1 decatherm

Table 13. Ten Largest Electric Boilers In The State

SIZE (BTU/hr)	FACILITY	MANU YEAR	USE	CITY
42,000,000	Western Zirconium	1988	Process	Ogden
5,815,000	Kanesville Elementary	1977	Hot Water Suppl	Kanesville
5,250,000	JC Penney	1967	Hot Water Heat	Salt Lake City
4,536,000	Intermountain Power Project	1984	Hot Water Heat	Delta
4,536,000	Intermountain Power Project	1984	Hot Water Heat	Delta
3,500,000	Pacificorp	1974	Hot Water Suppl	Salt Lake City
3,483,300	Delta Airlines GSE	1989	Hot Water Heat	Salt Lake City
2,750,000	Intermountain Power Project	1984	Hot Water Suppl	Delta
2,625,000	Pacificorp	1988	Power	Salt Lake City
2,526,000	ATK- Thiokol	1990	Process	Promontory

Table 14. Ten Oldest Electric Boilers

MAN YEAR	SIZE (BTU/hr)	FACILITY	FAC TYPE	USE	CITY
1955	250,000	Sego Lily Elementary	School	Process	Lehi
1955	35,000	Cleveland Elementary	School	Process	Cleveland
1958	84,000	Sally Murro Elementary	School	Process	Helper
1960	128,000	Parowan Elementary	School	Process	Parowan
1962	84,000	Longview Elementary	School	Process	Murray
1962	63,000	Tolman Elementary	School	Process	Bountiful
1972	40,000	Huntington Elementary	School	Process	Huntington
1963	84,000	Alta View Elementary	School	Process	Sandy
1963	63,000	Central Davis Jr. High	School	Steam Heat	Layton
1964	574,000	Tooele Jr. High	School	Process	Tooele
1964	100,000	Milford Valley Memorial Hospital	Hospital	Process	Milford
1964	76,000	Dixon Middle School	School	Process	Provo
1964	76,000	Sunset View Elementary	School	Process	Provo
1964	63,000	Bountiful Elementary	School	Process	Bountiful
1964	24,000	Viewmont Elementary	School	Process	Murray

Age of Boiler

The boiler database presents the age of boilers in terms of the year the boiler was manufactured. For the purposes of this study, it was assumed that the boilers were installed and put into operation the same year that they were manufactured.

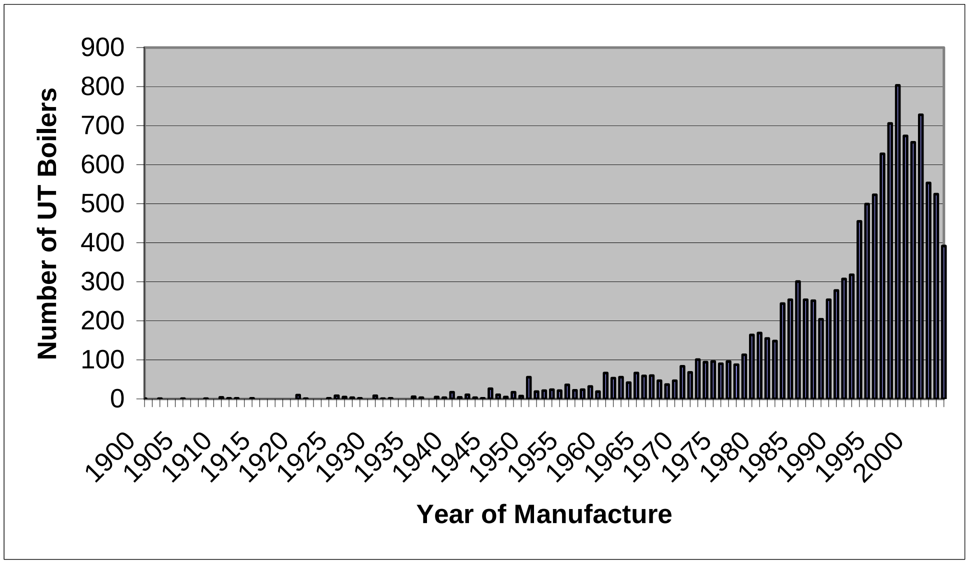
Examination of the database indicates that 9,012 (73%) of the active boilers in the state were installed within the past 20 years (since 1985); 2,456 boilers (20%) are 20 to 39 years old; 659 (5%) are 40 to 59 years old; and 136 (1%) are more than 60 years old. Table 15 presents the number of boilers that fall within selected age ranges.

Table 15. Number Of Boilers Listed For Each Age Range Based On Year Manufactured

BOILER AGE RANGE	NUMBER OF BOILERS	PERCENT OF TOTAL
<10 years	5,668	46 %
10-19 years	3,344	27 %
20-29 years	1,732	14 %
30-39 years	724	6 %
40-49 years	442	4 %
50-59 years	217	2 %
61+ years	136	1 %

Boiler age data are also presented in Figure 5, which illustrates the number of boilers installed each year in Utah.

Figure 5. Age of Active Boilers in Utah, by Year of Manufacture



The useful service life of most boilers is between 20 and 40 years depending upon fuel type, annual use, and maintenance history. Boilers less than 20 years old are not likely to require replacement; however, if a facility is currently heated with a boiler relying on an expensive fuel source, even a building with a very new boiler might remain a viable conversion project. Boilers greater than 40 years of age are often scheduled for replacement. Although some facilities managers maintain boiler systems that are up to 100 years old, it can be assumed that boilers over 60 years old would be good candidates for replacement. Table 16 presents selected information for the seven cities with the greatest number of boilers over 60 years old.

Table 16. Seven Cities With The Greatest Number Of Boilers Over 60 Years Old

CITY	NUMBER OF BOILERS	LARGEST (BTU/hr)	AVERAGE SIZE (BTU/hr)	Fuel Type
Salt Lake City	65	65,000,000	3,576,662	All Gas
Ogden	11	22,400,000	3,267,091	All Gas
Logan	9	3,360,000	893,333	All Gas
Provo	7	6,900,000	3,626,429	All Gas
Salina	6	11,432,000	3,202,333	5 Coal, 1 Gas
Brigham City	4	1,030,000	526,250	All Gas
Magna	3	350,000,000	350,000,000	All Coal

Facility Type

Although the boiler certificate database did not provide listings of facility type for boilers, the author was able to make an educated guess based on owner and location information. The categories are Private enterprise or unknown, School (includes public and private schools for grade 12 and lower), Church (includes all LDS buildings which could be schools, office, churches, etc.), Government (all levels of government including correctional facilities), Health (includes hospitals, clinics, rehab facilities, and, if identifiable, nursing homes and assisted living facilities), and Higher Education (includes public and private colleges and universities). A more in-depth examination of the boilers with a Private enterprise or unknown listing could reveal many of the facility types based on the owner and facility listed, but that level of analysis was beyond the scope of this study. Table 17 presents the number of boilers listed for each of the facility types provided in the database.

Table 17. Number Of Boilers Listed For Each Available Facility Type

TYPE OF FACILITY	NUMBER OF BOILERS	PERCENT OF TOTAL
Private enterprise or unknown	7,274	59 %
School	2,396	19 %
Church	945	8 %
Government	914	7 %
Health	446	4 %
Higher Education	333	3 %

Boilers with the greatest viability for conversion are those used in facilities that have a sustained demand for space heat and hot water and/or a large power or process demand, such as hospitals, nursing homes, prisons, and industries. Facilities that provide only space heat (such as civic and public assembly buildings) are not as viable for conversion as facilities that add a hot water load to the system (such as hospitals, prisons, some commercial buildings, schools, and dormitories with showers and kitchens).

For the purposes of this study, the facility type listed in the database was represented by an assumed facility utilization factor (FUF)(see appendix). The FUF is equivalent to the fraction of time a boiler is running at full capacity. Facilities with heavy or more uniform boiler demands have higher FUFs. Facilities with lighter or more intermittent boiler demands have lower FUFs. Hospitals, for example, have a relatively high facility utilization factor, whereas the FUF for a building used for public assembly would be relatively low.

For this study, FUFs were assigned based on the stated facility type; however, many other factors could affect actual boiler usage. For example, facilities with redundancy or over-capacity in the boiler system would have a lower FUF than a similar facility type without redundancy or over-capacity. The FUF is a relative index and cannot be used to directly estimate fuel consumption. Experience accumulated over the past year by CTA Architects and Engineers[f] in biomass projects suggests that the thermal profile and existing boiler usage for each facility is unique, and highly unlikely to be similar to the FUF assigned to that boiler's facility type. Table 18,

[f] CTA has the current contract with the Forest Service to perform pre-feasibility studies on potential biomass projects in the program region.

developed by CTA et al.[16], shows the impact of the facility utilization factor on annual fuel use for a 1 MMBtu/hour boiler for several fuel types.

Table 18. Impact Of FUF On Annual Fuel Use for a 1 MMBtu/hour Boiler

FUF	Annual Fuel Use		
	Fuel Oil (gals/yr)	Propane (gals/yr)	Natural Gas (dka/yr)
0.03	1,895	2,904	263
0.06	3,790	5,808	526
0.08	5,053	7,743	701
0.15	9,474	14,519	1,314

Hospitals, along with correctional facilities and some higher education buildings, were assumed to have the highest FUF of the facility types listed in the database, which makes them strong candidates for conversion. The database indicates that there are 446 boilers located in health facilities.

Boiler Use

The boiler database list 6 different kinds of boiler uses: space heating using water (water heating), space heating using steam (steam heating), hot water supply, process heat, power, and other. Table 19 presents the number of boilers listed for each of the uses provided in the database.

Table 19. Number Of Boilers Listed For Each Available Boiler Use

BOILER USE	NUMBER OF BOILERS	PERCENT OF TOTAL
Water Heating	4,334	35 %
Hot Water Supply	3,844	31 %
Process	2,490	20 %
Steam Heating	1,580	13 %
Power	48	< 1 %
Other	12	< 1 %

As indicated above, boilers that are used only for space heating are not as viable for conversion as boilers that are also used for supplying hot water supply (such as commercial buildings, schools and dormitories with showers and kitchens). Boilers with the greatest viability for conversion include those with a sustained demand for space heat and hot water such as hospitals, nursing homes, prisons, and industrial users (including facilities with a large power demand).

MARKET POTENTIAL FOR EXISTING BOILER CONVERSIONS TO WOODY BIOMASS FUEL

Determining the commercial potential of a product or service requires attempting to measure the likely degree of market acceptance. An accurate measurement requires analysis of a range of market, technical, economic, financial, and oftentimes broad stake-holder issues.

Using the data compiled in the previous section, this study attempts to identify the potential size and scope of a commercial wood-fired boiler market in Utah. The analysis is based solely on simple payback through annual fuel savings on a boiler conversion investment.[g] While limited in accuracy, simple payback[h] is an initial indicator, from a facility owner's point of view, of how attractive the investment in conversion would or would not be given current conditions. There is a range of other factors and drivers including receptivity to new technologies, confidence in availability and price stability with wood fuel, government subsidies, and logistical uncertainty of wood handling and storage. These issues are discussed in the next section, but an in-depth analysis of these factors is beyond the scope of this study.

The simple payback calculations rely on a set of assumptions regarding facility utilization factors, boiler efficiencies, fuel prices, and new boiler system costs. These assumptions and the equations used to calculate paybacks are presented in the Appendix. It is important to keep in mind that each facility is unique in its combination of site factors that need to be examined. This report is not intended to preclude an assessment of individual facilities. Two scenarios were developed to differentiate between payback periods when boiler replacement is likely necessary (payback if you are planning on replacing the boiler anyway), and when it is not (payback if boiler replacement not necessary). Table 20 presents the results of the analysis divided into the two scenarios:

Table 20. Payback Periods For All Boilers

PAYBACK SCENARIOS -- ALL BOILERS				
Payback if boiler replacement required	**Number of boilers**		**Payback if boiler replacement not necessary**	**Number of boilers**
< 5 years	84		< 5 years	15
5 to <10 years	158		5 to <10 years	88
10 to <15 years	257		10 to <15 years	160
15 to 20 years	245		15 to 20 years	191
> 20 years	11,407		> 20 years	11,697

[g] This section does not include commercialization for new facilities, but is limited to modification and/or replacement of existing boiler systems given the data for the state of Utah. New facility potential is addressed in a later section.

[h] "Simple Payback" measures the time required to recover investment costs. Though useful, it is a limited analysis because it ignores the time value of money. A more useful tool, but beyond the scope of this report is life cycle analysis. This is a "cradle to grave" approach that measures all costs (economics, social, and environmental) of inputs and outputs.

Tables illustrating the number of boilers in selected payback ranges sorted by existing fuel source, size, and county are presented in the Appendix.

For the purposes of this study, it was assumed that the commercial potential for conversion was strongest for boilers that have a *payback of 15 years or less*. The 15-year threshold is somewhat arbitrary, but is used to indicate a limit at which the attractiveness of the investment begins to diminish. This 15-year payback threshold may decrease or increase depending on a number of factors, including the type of facility (small business, hospital, school, nursing home, etc.). For example, it is expected that institutional facilities will have a greater tolerance for longer payback periods than small businesses. The recently enrolled bill, Energy Savings in State Buildings (HB 80 passed in 2006 General Session, Utah Legislature) states that energy savings agreements-- agreements entered into by a state agency whereby the state agency implements energy efficiency measures and finances the associated costs using the stream of expected savings in utility costs-- can be entered into for periods up to 20 years.[17]

Boilers Not Requiring Replacement -- Payback < 15 Years

The “lowest hanging fruit” for boiler conversion would be those boilers that have a payback period of less than 15 years even when boiler replacement is not required. In these cases, the annual fuel savings generated by the conversion would pay for the installation of a new wood boiler system in less than 15 years.

Table 20 indicates that there are 263 boilers with payback periods less than 15 years when boiler replacement is not required. These 263 boilers represent about 2% of all existing boilers in the state. Replacing all of these boilers with new wood burning boilers would require approximately $490 million in aggregate investment. Analysis of these boilers indicates that their existing fuel sources are varied, and all are greater than 3,000,000 BTU/hr size.

Boilers Requiring Replacement – Payback < 15 Years

The next “lowest hanging fruit” for boiler conversion would be those boilers that have a payback period of less than 15 years when boiler replacement is required. In these cases, the annual fuel savings generated by the conversion would pay for the *additional expense* of installing a new wood boiler over that required for a new gas boiler.

Table 20 also indicates that there are 499 boilers with payback periods less than 15 years when boiler replacement is required. These 499 boilers represent about 4% of all existing boilers in the state. Replacing all of these boilers with new wood burning boilers would require approximately $760 million in aggregate investment. Analysis of this group of boilers indicates that 3 of them are over 60 years old, and total of 178 of them are at least 30 years old; ages that indicate that they may be scheduled for replacement in the relatively near future.

The facility type for 225 of these boilers are private enterprises or unknown, but 42 are listed as government; 102 are listed as health; 12 are church related, including several that might be better categorized along with the 55 higher education; and 69 are listed as being located in schools. Most of these boilers list gas or gas/oil as their existing fuel source, but a few of them currently use another fuel source.

Thus far in this section we have analyzed information provided in the State's database of boiler certificates to help identify the potential market for converting existing boilers to use wood biomass. These analyses began to define this potential market and revealed several areas where further refinements could be made. Next, updated information and additional project assessment and design experience from the program to date is used to further analyze factors that help refine identification of the potential customer base for boiler conversions. Additional considerations are discussed to help further refine the relative opportunity for conversion based on the information available in the boiler database.

Increasing Existing Fuel Costs

The past year has shown the volatility of prices for fossil fuels. The socio/political/economic unrest in oil-producing nations has contributed to the price of oil topping $75 a barrel. There is also belief in the scientific community that the world's oil production will peak within the next few decades then begin a decline as it previously did in the U.S.[18] Along with the increasing demand for resources to fuel the industrial growth of some of the world's most populous nations, it is not likely that the price of oil will return to former levels. Refining capacity in the U.S. has also been stagnant for decades. Natural disasters also took their toll on infrastructure contributing to price hikes in natural gas as well as petroleum.

The price of petroleum affects the equipment use and transportation costs of moving wood from the forest to a facility. While increasing petroleum prices will contribute to the increased cost of wood fuel, it will likely be greatly outweighed by the fuel savings from woody biomass- over petroleum-based boilers.

Impact of Natural Gas Prices

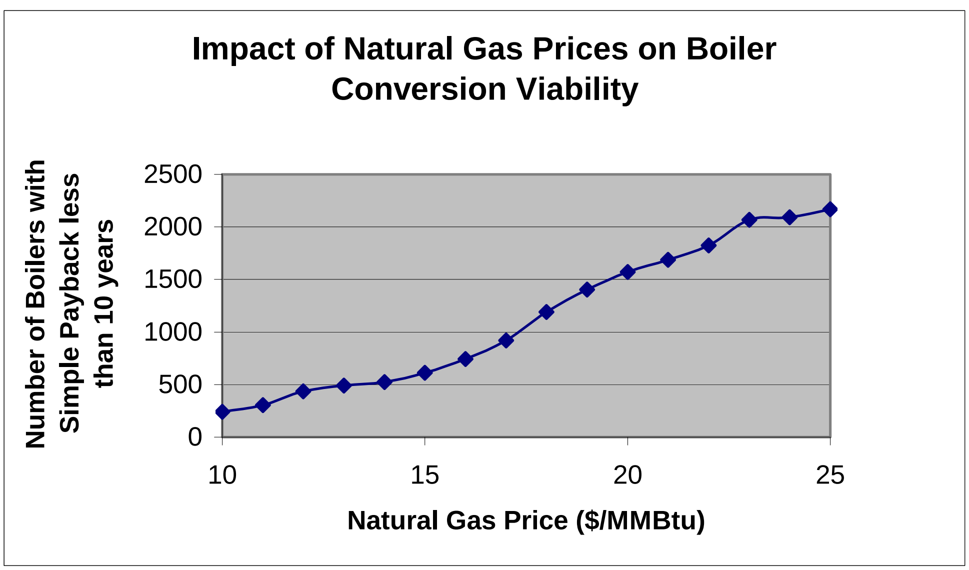
About 95% of existing boilers in Utah use natural gas as their only or primary fuel source. In this study it is assumed that natural gas is available for $10.00/MMBtu.[i] Rates continue to fluctuate and last winter the commercial and residential prices in Utah topped $12/MMBtu. Since natural gas prices appear to be increasing rapidly, it is interesting to explore the impact that increasing fuel costs might have on the viability of biomass boiler conversions. The impact of changing natural gas prices while the price of wood is held constant on the numbers of boilers with paybacks of less than 10 years is illustrated in Table 21 and Figure 6. It is worth noting that at 4% inflation, natural gas prices would double in 18 years (wood prices would likely also rise during that time, but not as much).

[i] The term MMBtu has been used to in this report to compare prices of fuels of varying heat contents sold in various units (e.g. gallons, tons) into a common $ per heat unit. MMBtu refers to one million British thermal units and is equivalent to a deca therm. Many residential customers purchase natural gas in therms or hundred cubic feet. A therm is a unit of energy equal to 100,000 Btus. A hundred cubic feet (CCF) is equal to 1.029 therms. In other words, $10/MMBtu equals $1 per therm and approximately $1 per CCF.

Table 21. Impact Of Natural Gas Prices On Numbers Of Boilers With Paybacks <10 Years

price of natural gas ($/MMBtu)	number of boilers with payback <10yrs	percent of boilers with positive payback
$10.00	242	2.0 %
$11.00	306	2.5 %
$12.00	434	3.6 %
$13.00	491	4.0 %
$14.00	525	4.3 %
$15.00	612	5.0 %
$16.00	743	6.1 %
$17.00	921	7.6 %
$18.00	1,192	9.8 %
$19.00	1,405	11.6 %
$20.00	1,570	12.9 %
$21.00	1,687	13.9 %
$22.00	1,823	15.0 %
$23.00	2,069	17.0 %
$24.00	2,092	17.2 %
$25.00	2,169	17.9 %

Figure 6. Impact Of Natural Gas Prices On Numbers Of Boilers With Paybacks <10 Years



Facility Types with Majority of Eligible Boiler Conversions

Table 20 indicates that there are 263 boilers with paybacks of less than 15 years, 103 with payback of less than 10 years, 51 with paybacks of less than 7 years, and 15 boilers with paybacks of less than 5 years.

Of the 103 boilers with paybacks of less than 10 years, 45 were listed as *Private or unknown* for the facility type, 23 listed *health*, and at least 24 were listed as *higher education*. As described in an earlier section of this report, public institutions may have financial structures that can tolerate longer payback periods as compared to businesses that may require payback periods of less than 5 years.

These values suggest that of the facility types for which we have information, hospitals and higher education appear to be facility types with the greatest number of boilers that appear to be most eligible for conversion.

Boiler System Size and Type

CTA's experience to date suggests that biomass boilers that are 1 MMBtu/hour or smaller would likely best be designed to use wood pellets as their fuel source; boilers greater than 1 MMBtu/hour are better suited to using wood chips. Analyses conducted for this study indicate that none of the boilers with a payback of less than 10 years are smaller than 1 MMBtu/hour. This suggests that pellet boilers are less likely to be appropriate for those projects that are good candidates for conversion, but pellet systems may be very viable when incorporated into new construction.

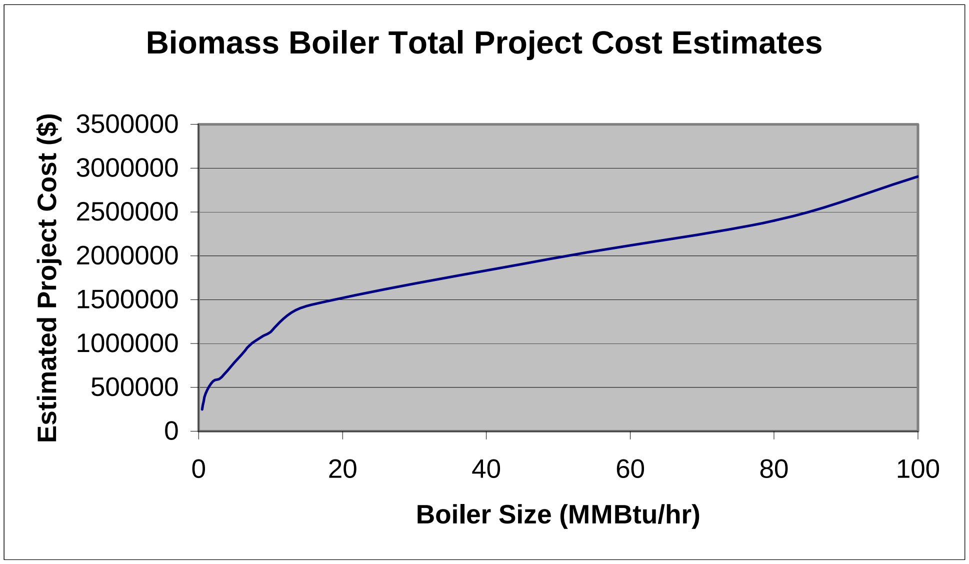
Small boilers systems are disadvantaged because they are likely to have a lower annual fuel use and insufficient annual fuel savings to cover conversion to biomass. Small biomass systems are also more expensive on a per-unit basis than large systems. For very small systems, fossil fuel system costs are very low in comparison to wood systems.

There are two small gasification boiler systems that can use woodchips as the feedstock coming into the marketplace that appear to have lower initial capital investment costs. These systems fit the <1 MMBtu per hour range and could significantly alter the economics of using wood with small systems

Total Project Cost vs. Boiler Size

The payback analyses presented in this report use a boiler cost curve that was developed by the author based on industry information and previous studies as discussed in the appendix. This curve is presented in Figure 7.

Figure 7. Boiler System Cost Based On Boiler Size For Boilers 0.5 To 100 MMBTU/Hour



As might be imagined, biomass boiler projects benefit from economies of scale; that is larger projects are less expensive on a $ per heat unit basis than are smaller projects. This is illustrated in Figure 8.

Figure 8. Biomass Boiler Cost Per Unit Size

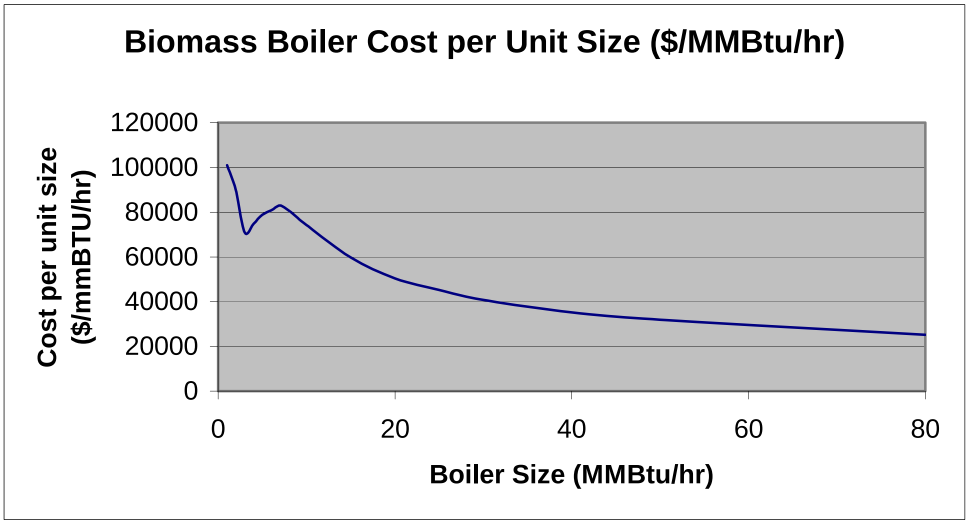


Figure 8 illustrates that boilers sized around 1 MMBtu/hour are not optimal from an economic standpoint. Energy analysis might indicate that a smaller boiler would achieve optimal performance, but smaller boilers can actually be more expensive than slightly larger boilers in the 1 MMBTU/hour range. This size is at the upper end of the size range for pellet systems, and at the low end of the size range for wood chip systems. Pellet heating technology is also geared towards very small systems (less than 500,000 BTU/hour); above 500,000 BTU pellet system manufacturers have less experience. The hiccup in the cost per unit reflects the boiler type. There are more options for boilers in the smaller ranges. As size increases, water tube boilers become more prevalent, and they tend to have a significantly higher price. The dynamic change occurring as a result of higher fossil fuel prices could change the market fairly quickly as there are boilers manufactured in Europe and Japan that could be imported to the U.S.

Smaller pellet systems face a set of additional cost barriers:

- Wood heating system (pellet and chip) manufacturers are very busy (backlogged orders)
- There is a lack of experience in bidding pellet projects
- Some states require ASTM certification on boilers. Many pellet heating systems are made outside the U.S. and don't have this certification; obtaining this certification adds cost to the system.

The cost of the boiler is only part of the cost of conversion. There will be costs to integrating the new system into existing infrastructure. It may also be necessary to house the larger boiler along with fuel supply in a new building. All of this depends on the specifics of the system being converted. Estimates were added to the boiler costs for the calculations in this study (see appendix for discussion). CTA has cost-saving recommendations resulting from some of the experiences of conversion of facilities in the region. They can be found in the updated Montana Boiler Study.[19]

Best Conversion Opportunities

The analyses of conversion opportunities presented in this report are based on project economics, represented by total project cost and simple payback of those initial costs from fuel savings. Based on these analyses of the boiler database and the assumptions made in this report, there are 263 boilers with a simple payback of less than 15 years, 103 with a payback of less than 10 years, 51 with a payback of less than 7 years, and 15 boilers with a payback of less than 5 years.

The best opportunities for conversion are those boilers with a payback of less than 10 years. The basic characteristics of the 103 boilers with a payback less than 10 years are illustrated in Figures 9 to 11 below. Note that the number of boilers with paybacks of less than 10 years reflect both project economics and the total number of boilers that exist in each category. It is important for the reader to realize that each individual facility will have its own unique characteristics that will be different from the assumptions used in this study.

Figure 9. Existing Fuel Types Of Boilers With Paybacks Of Less Than 10 Years

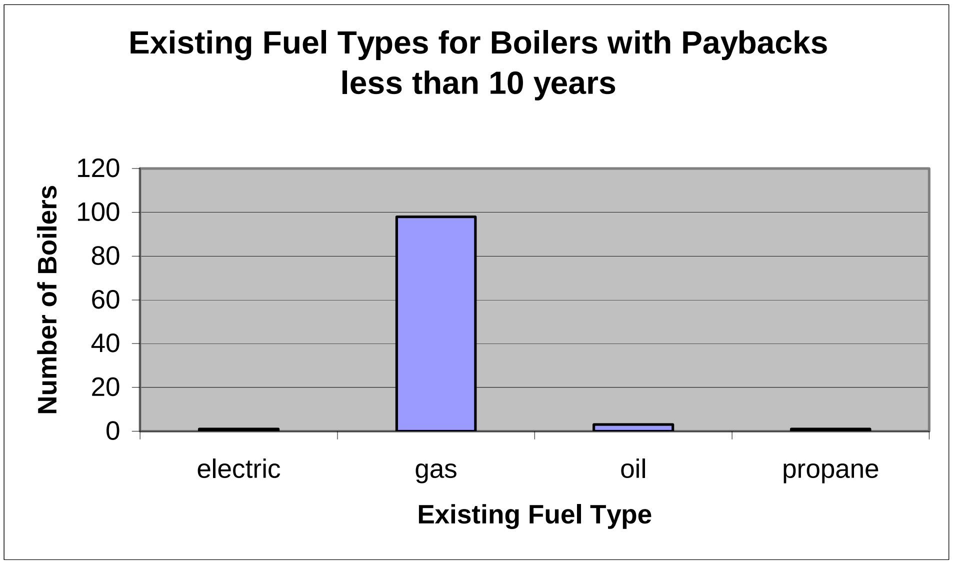


Figure 10. Facility Types Of Boilers With Paybacks Of Less Than 10 Years

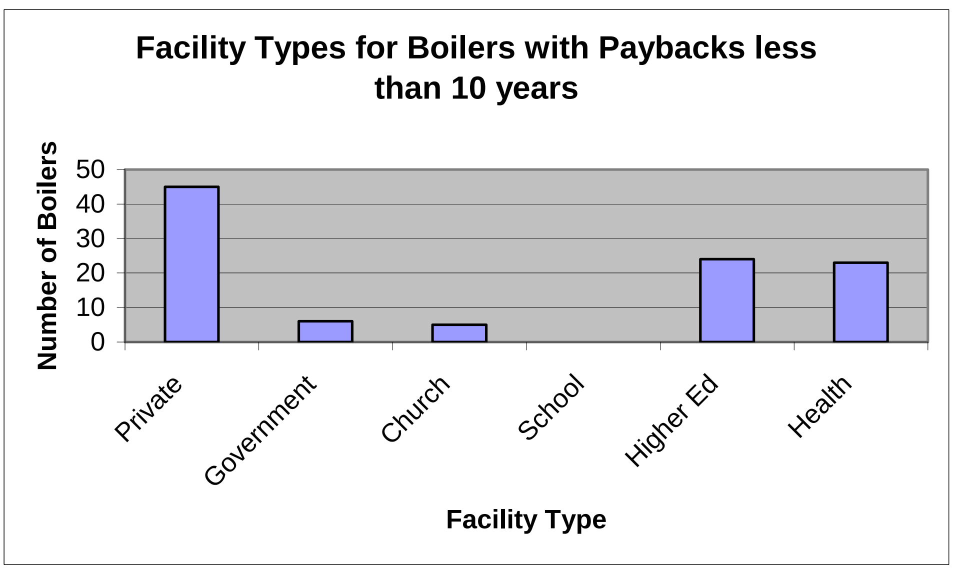
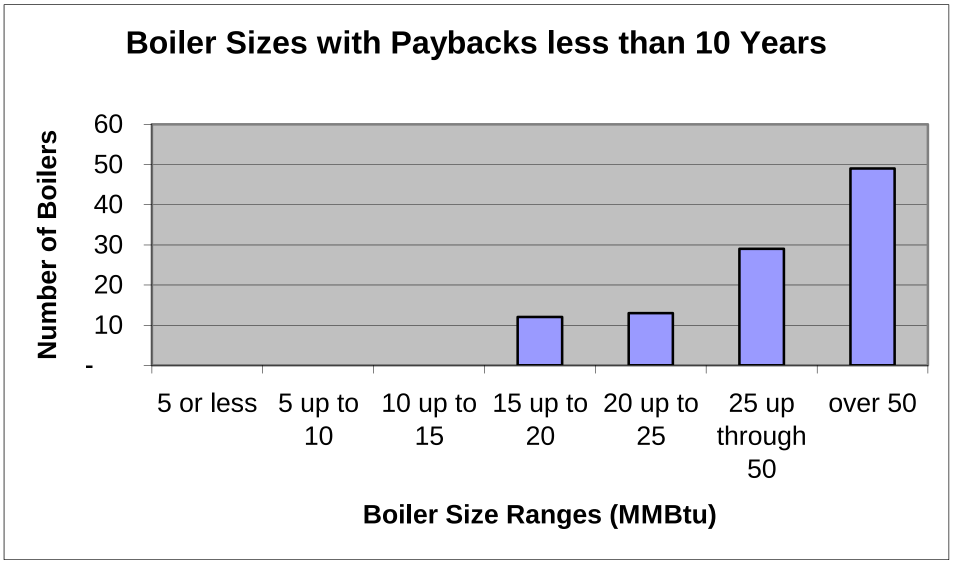


Figure 11. Sizes Of Boilers With Paybacks Of Less Than 10 Years



As discussed earlier in this report, facility owners have differing financial expectations, risk tolerances, and structures. Educational institutions and government agencies are likely able to take a longer financial view than private sector facilities. And they are likely able to encompass the larger picture of biomass benefits that affect the environment but not always appear on the business ledger. Universities, in particular, may have additional educational drivers for using wood biomass and other renewable energy for heating facilities. For this reason, boilers with paybacks less than 10 years that are located at universities, hospitals, or other facilities with high utilization rates appear to represent the best opportunities for conversion.

NEW CONSTRUCTION INSTALLATIONS AND OTHER WOODY BIOMASS ENERGY USES

An even greater potential market than existing boiler system conversions to biomass may be installations in new construction projects. The costs of integrating a new boiler system into an existing distribution system are avoided, and adequate space for the boiler, chip storage, and fuel delivery can be configured into the plans. When designing a new building, it is possible to more carefully match the biomass system size to the projected heating load, thereby minimizing heating system costs. If a new facility combines the use of conventional and biomass fuels, the biomass system does not need to meet 100% of the load. This allows the biomass system to work more effectively, with the fossil fuel source operating at low load and peak load conditions and serving as a backup fuel source. New installations are also a good opportunity for wood pellet systems that use an array of small boilers linked together to match load. The potential numbers and locations of new construction projects involving biomass heat will likely be determined based on: (1) the projected location and rate of new construction (development), and (2) the viability of biomass boilers in new installations associated with potential development.

There are two components in estimating the potential for biomass boiler installations in new construction projects: (1) predicting new construction projects and (2) predicting which of these new construction projects might be viable for biomass boilers. In this section, projections using boiler installation data from the last 10 years as a basis for predicting boiler installations for the next 10 years are presented.

Projections Based On Boilers Installed In Last Ten Years

The boiler database was analyzed to determine the characteristics of boilers installed over the past 10 years. This information can be used as one prediction of the numbers and characteristics of boilers that might be installed in the state over the next 10 years.

Analysis of the boiler database indicates that over the last 10 years (1995 through 2004) there were 6,188 boilers installed in Utah. The database does not indicate if these boilers were replacements or new construction installations. Using the past as a predictor of the future, these numbers suggest that an average of 619 boilers will be installed in Utah each year.

Boiler Installations By Year

The number of boilers installed each year in Utah for the past 10 years is illustrated in Figure 12 and presented in Table 22. The values in this table suggest that the numbers of boilers installed each year over the past year has fluctuated, possibly correlated with the general state of the economy where more boilers are installed in years of growth and prosperity. The drop starting in 2002 could represent the economic slowing of the last few years and/or the end of the building leading up to the 2002 Winter Olympics held in the state.

Figure 12. Number of Boilers Installed in Utah Each Year For the Past 10 Years

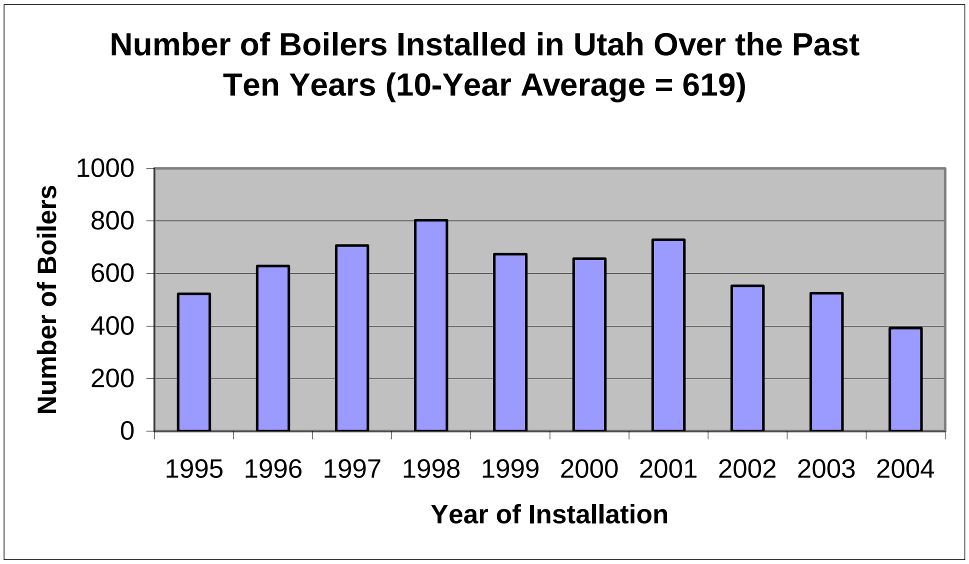


Table 22. Number Of Boilers Installed In Utah Each Year For The Past 10 Years

Year of Installation	Number of Boilers
1995	523
1996	628
1997	705
1998	803
1999	674
2000	657
2001	728
2002	553
2003	525
2004	392
Average	619

Boiler Installations By Facility Type

The numbers of boilers installed over the past 10 years by facility type is listed in Table 23. Although most of the boilers listed in the database were determined to be Private Enterprises (or not known to be one of the other categories) under the facility type, this information suggests that almost 100 boilers are installed each year in K-12 schools, and 25 are installed each year in health facilities such as hospitals, assisted living facilities, clinics.

Table 23. Number Of Boilers Installed In Utah In The Last 10 Years By Facility Type

Facility Type	Number of Boilers	Percent Of Total
Private Enterprise or Unknown	3,749	61 %
School	1,162	19 %
Government	492	6 %
Church	351	8 %
Health	255	4 %
Higher Education	179	3 %

As previously noted, high and sustained draw on a facility's thermal profile (heat and hot water demands) make better candidates for biomass boiler systems. It is important to note, however, that all of the boilers located in hospitals, assisted living facilities, and rest homes may or may not be used for heat and hot water demands – some may be used for sterilization, space heat only, or be very small systems that would not be viable as biomass systems. In these cases, the boilers would not produce the same savings as steam boilers in, say, hospitals that produce space heat, domestic hot water, and cooling using absorption chillers. The above numbers have not been adjusted to take that into account. A detailed examination of a particular facility would need to take place to determine the extent of biomass integration feasibility.

Boiler Installation By Size

The number of boilers installed in Utah over the past 10 years by boiler size (BTU/hr) is listed in Table 24.

Table 24. Number Of Boilers Installed In Utah In The Last 10 Years By Boiler Size

Boiler Size (BTU/hr)	Number of Boilers	Percent of Total
<= 500,000	2,955	48 %
500,001to <1,000,000	1,267	21 %
1,000,001 to 10,000,00	1,825	29 %
10,000,001 to 20,000,000	71	1 %
20,000,001 to 50,000,000	49	<0.1 %
> 50,000,000	19	<0.1 %

Although systems are now being developed to manage and convey wood chips for smaller systems, program experience to date suggests that boilers less than 1,000,000 BTU/hr in size are better candidates for using wood pellets rather than wood chips. Currently, the most problematic size range appears to be between 800,000 and 1,000,000 BTU/hr. Boilers in this size range are larger than many wood pellet heating system manufacturer's standard sizes yet smaller than many wood chip heating system sizes. Connecting a series of wood pellet systems together, some to handle the base load and others drawn on as needed, could overcome the problem of that size range. There are a couple of wood gasification systems coming into the marketplace that appear to fit this size range and would not need to replace the whole boiler. The wood chips are heated, and the resulting gas could be fed into an existing gas boiler. This could significantly change the potential for conversion in these small boiler size ranges.

Equivalent Wood Fuel Value

Table 25 presents the number of boilers installed in Utah over the past 10 years categorized by the wood fuel value equivalent (MMBtu/year).

Table 25. Number Of Boilers Installed In Utah In The Last 10 Years By Wood Fuel Value Required

Wood Fuel Value Required (MMBtu/year)	Number of Boilers	Percent of Total
<2,500	5,292	86 %
2,500 to <5,000	564	9 %
5,000 to <10,000	183	3 %
10,000 to 20,000	67	1 %
> 20,000	82	1 %

Experience in the program so far suggests that biomass boiler projects with fuel requirements less than 2,500 MMBtu/year are unlikely to be viable (except under unique circumstances). Using this value as a guideline, only 896 (about 14%) of the 6,188 boilers installed over the past 10 years in Utah would have been viable as biomass systems.

Analysis of the database suggests that if all of those 896 boilers installed in Utah over the last 10 years used wood as a fuel source, they would require an estimated total of 8,632,644 MMBtu/year wood fuel value, or an average of 9,635 MMBtu/year per boiler. Assuming the fuel value of wood is 10.8 MMBtu/ton (at 40% moisture), this translates to an equivalent of 799,319 tons of wood per year for all of those boilers, or an average of 892 tons of wood per year per boiler

Using the past as a predictor of the future, this information suggests that about 90 boilers will be installed each year that would be viable as biomass systems. If each of those 90 boilers installed each year were fueled by woody biomass, that would translate to a new wood demand of 80,289 tons of wood per year, which could be generated from thinning approximately 8,000 acres per year, based on 10 tons of excess biomass per acre.

Boiler Installation By Fuel Source

Table 26 presents the number of boilers installed in Utah over the past 10 years categorized by the fuel source used. Similar to the overall database, 97% of the boilers installed over the past 10 years use natural gas as their fuel source.

Table 26. Number Of Boilers Installed In Utah In The Last 10 Years By Fuel Source

Fuel Source	Number of Boilers	Percent of Total
Natural Gas	6,003	97 %
Electric	111	2 %
Propane	42	1 %
Oil	16	<1 %
Other	15	<1 %
Wood	0	0 %
Coal	1	0 %

Boiler Installation By Boiler Use

Table 27 presents the number of boilers installed in Utah over the past 10 years categorized by boiler use. One-third of these boilers (33%) were installed for space heating using water as the medium, the most feasible type of system for use with biomass.

Table 27. Number Of Boilers Installed In Utah In The Last 10 Years By Boiler Use

Boiler Use	Number of Boilers	Percent of Total
Hot Water Supply	2,548	41 %
Space Heating - Water	2,078	33 %
Process	1,144	18 %
Space Heating - Steam	389	6 %
Power	23	< 1 %
Other	6	< 1 %

Potential For Increased School Construction

The Bureau of Economic and Business Research[20] has predicted a boom in Utah's school age population. The exact magnitude is unknown, but given a range of reasonable growth and fertility assumptions, the number of school age children will increase significantly starting in 2004. The boom for K-12 schools will have run its course by 2020, but the wave will then impact higher education, particularly from 2016 to 2025.

Utah's demographic characteristics include a higher than average fertility rate, a lower than average median age, and a higher than average school-age dependency ratio. The educational implications are that Utah will have the highest class size (student per teacher ratio) and the lowest per-pupil funding in the nation.

The growth in numbers of school age children will not be consistent across the state. Some counties will experience significant growth, particularly along the Wasatch front, while some of the rural counties may even experience a loss. Figure 13 and Table 28 shows the projected cumulative school age population increase from 2000 to 2030.

Figure 13. Projected Cumulative School Age Population Increase: 2000 to 2030

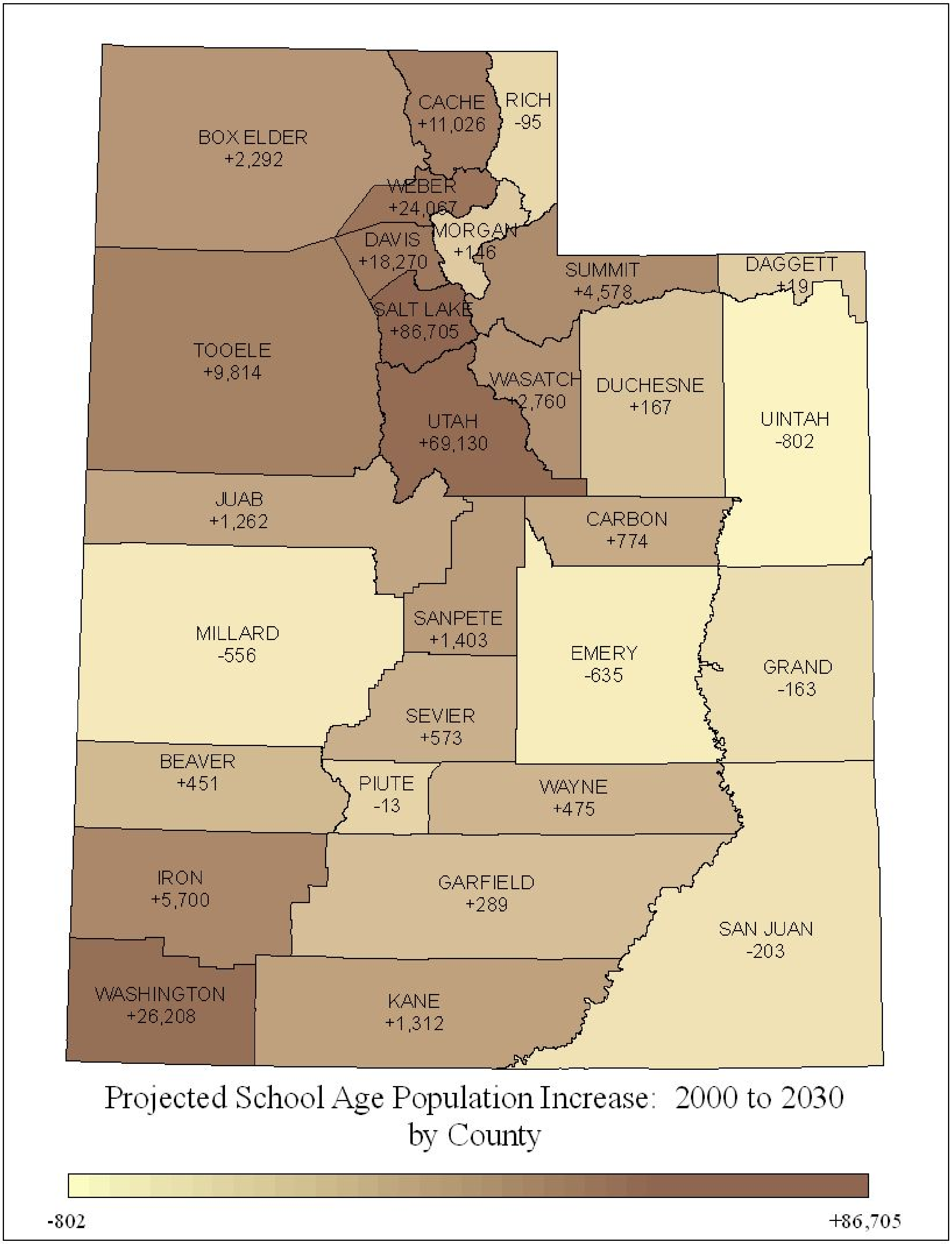


Table 28. Projected Cumulative School Age Population Increase: 2000 to 2030

County	Projected Increase (Loss)
Beaver	451
Box Elder	2,292
Cache	11,026
Carbon	774
Daggett	19
Davis	18,270
Duchesne	167
Emery	(635)
Garfield	289
Grand	(163)
Iron	5,700
Juab	1,262
Kane	1,312
Millard	(556)
Morgan	146
Piute	(13)
Rich	(95)
Salt Lake	86,705
San Juan	(203)
Sanpete	1,403
Sevier	573
Summit	4,578
Tooele	9,814
Uintah	(802)
Utah	69,130
Wasatch	2,760
Washington	26,208
Wayne	475
Weber	24,067

Projected Population Growth By Area

The Governor's Office of Planning and Budget and the seven Associations of Government in Utah released population projections for Utah's counties and cities in 1995.[21] Utah's counties will experience various levels of growth over the next 50 years. High growth is projected to be concentrated in counties within or adjacent to the Wasatch metropolitan region and in the southwestern portion of the state. The county that will have the highest projected average annual rate of change is Washington County, followed by Morgan, Summit, Wasatch, and Tooele. Other counties expected to grow faster than the state average are Utah, Iron, Cache, and Beaver. While no county is expected to experience negative growth, several are expected grow less than 1% per year. These counties are predominantly located in the central and eastern portion of the state. Figure 14 and Table 29 shows the Population Projections by County to 2050.

Figure 14. Population Projections by County for 2050.

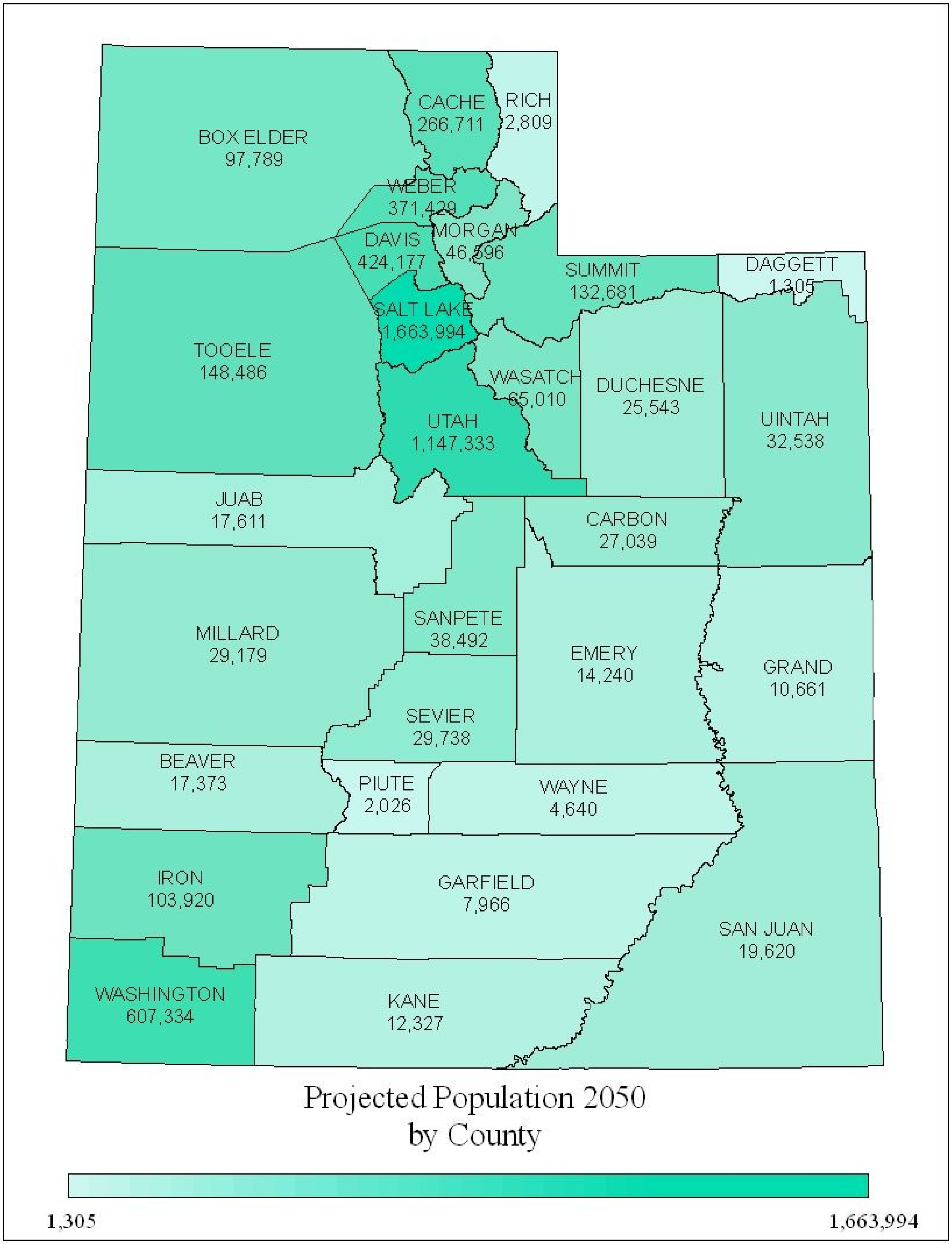


Table 29. Population Projections by County to 2050

County	Population in 2000 census	Projected Population in 2050	Average Annual Rate of Change 2000 to 2050
Beaver	6,023	17,373	2.1%
Box Elder	42,860	97,789	1.7%
Cache	91,897	266,711	2.2%
Carbon	20,396	27,039	0.6%
Daggett	933	1,305	0.7%
Davis	240,204	424,177	1.1%
Duchesne	14,397	25,543	1.2%
Emery	10,782	14,240	0.6%
Garfield	4,763	7,966	1.0%
Grand	8,537	10,661	0.4%
Iron	34,079	103,920	2.3%
Juab	8,310	17,611	1.5%
Kane	6,037	12,327	1.4%
Millard	12,461	29,179	1.7%
Morgan	7,181	46,596	3.8%
Piute	1,436	2,026	0.7%
Rich	1,955	2,809	0.7%
Salt Lake	902,777	1,663,994	1.2%
San Juan	14,360	19,620	0.6%
Sanpete	22,846	38,492	1.0%
Sevier	18,938	29,738	0.9%
Summit	30,048	132,681	3.0%
Tooele	41,549	148,486	2.6%
Uintah	25,297	32,538	0.5%
Utah	371,894	1,147,333	2.3%
Wasatch	15,433	65,010	2.9%
Washington	91,104	607,334	3.9%
Wayne	2,515	4,640	2.2%
Weber	197,541	371,429	1.3%
State of Utah	**2,246,553**	**5,368,567**	**1.8%**

Opportunities for Gasification

Gasification refers to heating organic solids and liquids with limited oxygen to produce a synthetic gas that can be used to generate heat in a furnace or generate power by turning a turbine. A number of firms have been developing gasification technology using wood. Some have focused on gasification systems for large industrial users such as wood mills. Several other firms and research centers are working toward the commercialization of smaller gasification systems projected to be in the 200,000 to 1,000,000 btu/hour size range. This technology may reduce the initial capital investment of biomass conversion if the gas produced is used in conjunction with an existing gas-fired boiler to produce heat rather than to generate power. As these systems come into the market, the financial viability of small scale wood boiler systems may improve.

Opportunities for Cooling

Absorption chillers have been incorporated into the steam cycle of some facilities heated with wood to provide chilled water for cooling. The University of Idaho in Moscow and Chadron State College in Nebraska have added this technology to their wood-fueled boilers to both heat and cool their college campuses.

For such a system to be feasible, there needs to be a significant demand for cooling over many months of the year. The University of Idaho's annual heating load is roughly equal to the annual cooling load, for example. Because absorption chillers require the production of steam, facilities that rely on hot water heating systems would not be able to utilize this technology. If cooling is desired, the potential use of absorption chillers needs to be addressed early in the project's design and development.

Opportunities for District Heating

The prediction above assumes that new boiler installations will follow patterns similar to past installations – that is one or more boilers are installed to serve a single facility. An alternative installation scenario is district heating, where steam or hot water generated by one or a set of boilers is distributed to multiple buildings. This is more common in European countries.

The potential exists for using biomass boilers for district heating in new construction projects in Utah. Rather than putting individual heating and cooling systems into each home or building, the systems could be linked to run off a single biomass unit. Other potential applications would be in the "box store" retail areas or industrial parks, or in existing or expanding university, government, retirement, and health care campuses across the state. In both cases, it is believed that the greatest viability would be achieved if the concept of district heating were introduced early in the process, such as during master planning.

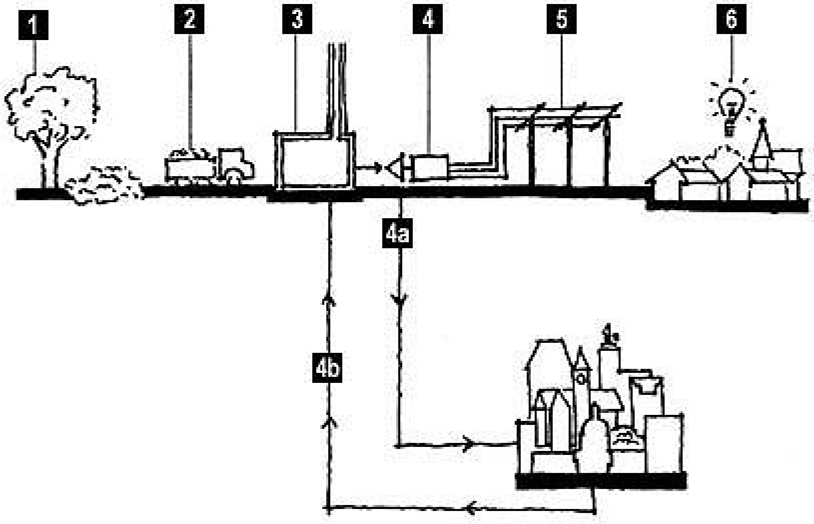
One example of a biomass district heating system is District Energy St. Paul in Minnesota. According to their website:[22]

> District energy systems produce hot water, steam or chilled water at a central plant and then distributes the energy through underground pipes to buildings connected to the system. Individual buildings do not need boilers, chillers or cooling towers. Customers use the hot and chilled water to meet their space heating, water heating, processing and air-conditioning needs. Once used in customer buildings, the water is returned to the central plant to be reheated and re-chilled and then re-circulated through the closed-loop piping system.

> District Energy St. Paul uses wood chips (biomass), natural gas, oil or clean-burning coal to fuel its district heating and cooling systems. With the April 2003 startup of an adjacent wood-waste-fired combined heat and power facility, managed by an affiliate, the company reduced its reliance on coal and oil by 80 percent. This produces significant environmental benefits and helps the community solve a local wood waste disposal problem. Our customers benefit from reduced costs, yet another fuel source, and the knowledge that they are using an environmentally sustainable source of "green energy" to heat and cool their buildings.
>
> District energy systems offer many environmental benefits. They increase energy efficiency; reduce air pollution; decrease emissions of ozone-depleting refrigerants; combat global warming; enhance fuel flexibility; facilitate the use of renewable energy; and help manage the demand for electricity.

Figure 15, again from the St. Paul District Energy website, diagrams the process of turning biomass into district heat and power using their combined heat and power plant.[23]

Figure 15. Combined Heat and Power Diagram



1. Wood waste, in the form of chipped tree trimmings and industrial wood waste, is collected by local companies and municipalities.

2. These wood chips are delivered to the CHP plant.

3. Chips are burned in new wood-fired boilers creating "green energy" to produce steam,

4. which turns an electricity-producing generator.

4a. To complete the CHP process, "waste" energy from making electricity is captured for use in District Energy St. Paul's hot water system to heat downtown buildings.

4b. Once the thermal energy has been extracted from the water by District Energy's customers, the water is returned to the boilers where wood is burned to produce steam once again.

5. The electricity travels through underground distribution lines to "The Grid," an interstate transmission delivery system.

6. Providing "green" electricity to residential and commercial customers.

Opportunities for Combined Heat & Power

Cogeneration, commonly known as combined heat and power (CHP), is the simultaneous production of heat and electricity from a single fuel. More heat and electricity are produced for a lesser amount of fuel through cogeneration than by separate heat and power units. Wood heating systems have been used to generate power by using waste heat to boil water that generates steam to turn a turbine or by using steam to operate a piston or turbine.

Biomass gasifier technologies are being evaluated in which the biomass is turned into a gas by heating it in an oxygen-controlled environment. This gas is used directly in a gas turbine to drive a generator, and the waste heat from the gas turbine may be used to drive a secondary steam turbine. Waste heat turbine systems are still in the developmental stages, and do not appear to be commercially available in the United States. Steam turbines continue to be manufactured and installed throughout the country.

Electrical load profiles and steam flows are required to determine project viability; these data are not available from the boiler database. Boilers in the database listed as providing power vary in size from 21,000 to 6,600,000,000 BTU/hr in size; however, many gaps in the data exist.

Based upon research done for the wood heating system at the University of Montana-Western campus in Dillon, a steam turbine capable of providing approximately 150 kw would add approximately $850,000 to the project cost. The turbine would require at least a 200-psi boiler, operating at 150-psi or less. The boiler is piped in a manner that allows the steam to flow through the turbine or through a separate pressure reducing station. The changeover is typically automated to reduce the risk of the turbine tripping off-line, or building excessive steam pressure.

The ideal combined heat and power system would operate 24 hours a day, 365 days a year with steam flows greater than 10,000 pounds per hour. Times of reduced power demands could allow selling power back to the grid, although local utility providers may not have a need for the surplus power generated by this system during off-peak hours. Often net metering results in the utility purchasing power back for less than the cost of production. Therefore, it is best if the power produced is used internally to offset the costs of purchased electricity. Combined heat and power systems may require additional staffing to monitor the high pressure steam system, further eroding any potential savings.

The greatest limitation on co-generation appears to be steam flow. Combined heat systems with the best paybacks are designed around steam flows of 10,000-15,000 pounds/hour. Many facilities in Utah may only achieve steam flows at those levels intermittently. Two common mistakes when installing a CHP system are under- or over-sizing the steam boiler system. Boilers less than 100 lbf/in2 (689 kPa) cannot provide adequate steam quality for turbine operation, while over-sizing the system results in additional capital costs but not better quality steam.

Table 30 shows a listing of the Combined Heat and Power Units located in Utah. The source[24] appears to not be current as some of the facilities are no longer in operation, (including Geneva Steel and the two facilities that list the fuel type as wood), and there was a 3 MW system recently dedicated at the Salt Lake County Landfill.

Table 30. Combined Heat And Power Units Located In Utah

City	Organization Name	Facility Name	Application	Op Year	Prime Mover	Capacity (kw)	Fuel Type
Altamont	Methanol Production Corporation	Methanol Production Corp. Utah #1 Plant	Chemicals	1987	B/ST	846	WAST
East Carbon	Sunnyside Cogeneration Associates	Sunnyside Cogeneration	Utilities	1999	CT	53,000	COAL
Layton	Wasatch Energy Systems	Davis County Landfill	Solid Waste Facilities	1986	B/ST	1,600	WAST
Logan	Utah State University	Utah State University	Colleges/Univ.	2003	CT	5,000	NG
Ogden	PacifiCorp	Little Mountain	Wastewater Treatment	1971	CT	16,000	NG
Ogden	Central Weber Wastewater Treatment Plant	Central Weber Wastewater Treatment Plant	Wastewater Treatment	2000	ERENG	1,246	BIOMASS
Panguitch	Ashley Valley Engineering	Panguitch Micro Energy Cogeneration, Inc	Wood Products	1990	B/ST	4,250	WOOD
Rowley	U.S. Magnesium / Renco Metals, Inc.	Magnesium Corporation Of America	Fabricated Metals	1972	CT	37,200	NG
Salt Lake City	Tesoro Petroleum Corp	Salt Lake City Refinery	Refining	2004	CT	30,000	NG
Salt Lake City	Energy Strategies Inc./Ihc Hospitals Inc	Primary Children's Medical Center	Hospitals/Healthcare	1990	ERENG	1,800	NG
Salt Lake City	J.A. Trent & Associates, Inc.	John T. Dunlop	Misc. Services	1987	ERENG	30	NG
Snowbird	Snowbird, Ltd./ Lone Peak Partners	Snowbird Ski Resort	Hotels	1986	ERENG	1,950	NG
Springville	City of Springville	Whitehead	Utilities	1986	ERENG	34,400	NG
Syracuse	No. Davis Co. Sewer Improv. Dist.	No. Davis Co. Sewer Improv. Dist.	Wastewater Treatment	1998	ERENG	1,400	BIOMASS

Tremonton	La-Z-Boy Chair Company, Inc.	La-Z-Boy Chair Company	Furniture	1986	B/ST	290	WOOD
Vineyard	Geneva Steel	Geneva Steel	Primary Metals	1944	B/ST	50,000	WAST

Prime Mover Code	Description	Fuel Code	Description
B/ST	Boiler/Steam Turbine	BIOMASS	Biomass, Land Fill Gas, Digester Gas, Bagasse
CC	Combined Cycle	COAL	Coal
CT	Combustion Turbine	NG	Natural Gas, Propane
FCEL	Fuel Cell	OIL	Oil, Distillate Fuel Oil, Jet Fuel, Kerosene, RFO
MT	Microturbine	WAST	Waste, Municipal Solid Waste, Black Liquor, Blast Furnace Gas, Petroleum Coke, Process Gas
ERENG	Reciprocating Engine	WOOD	Wood, Wood Waste
OTR	Other	OTR	Other

Opportunities for Co-Firing

Co-firing refers to replacing some percentage of coal with biomass. The Department of Energy estimates that 20 utilities across the nation are co-firing biomass with coal in the production of electricity. In Utah, 95% of net electrical generation is from coal,[25] as evidenced by the largest boilers in the state database being coal-fueled boilers owned by utilities. In addition, other states purchase Utah's surplus coal-generated electricity. Some of these states (i.e. California) have renewable portfolio standards that require some percentage of their energy come from renewable sources. To meet the needs of those states, Utah electricity producers will have to consider renewables, including biomass co-firing. Because existing equipment can be used with minor modifications, co-firing is much less expensive than building a new biomass power plant. Trials have shown that substitutions of biomass energy from 10% to 15% of the total energy input can be made.

Biomass can be more expensive than coal on a $ per heat unit basis (adding approximately $.02 per kWh which is similar to the premium charged by the Blue Sky program for wind generated power), but the extra fuel cost may be offset by the emerging market for saleable/tradable credits. The benefits of co-firing are reduced emissions (such as sulfur oxides, nitrous oxides, mercury, and carbon dioxides) and use of a renewable resource in electrical generation. These result in renewable energy certificates or credits (green tags) and emission credits for the utility that represent the environmental attributes of the renewable energy generation. NOx and SOx credits can be sold separately from the power generated. Congress recently extended federal renewable energy production tax credits as part of the Tax Relief and Health Care Act of 2006 (HR 6408). Section 201 of the Act provides a $.019 per kWh tax credit for the production of electricity produced from closed-loop biomass resources including co-firing and $.01 per kWh for open-loop biomass systems. The credit is available for ten years to closed-loop facilities and for five years to open-loop facilities that come online prior to January 1, 2009.[26]

The Southern Company conducted one recent co-firing study, testing several forms of biomass co-firing in utility pulverized coal power plants.[27] The following paragraph highlights some of the observations from their test.

There are two main co-firing approaches. The first approach, direct injection, introduces ground biomass pneumatically into the boiler through dedicated burners. This method requires separate on-off controls, but higher co-firing percentages are achievable. The second approach is co-milling where the biomass is mixed with coal and introduced into the boiler through the coal handling systems. This is the method they used to co-fire with wood. Its advantages are reduced capital costs and minimal on-site processing costs. Because coal has a higher btu content per volume, only up to 4% of total energy input from wood was possible using this method without de-rating their unit. There can be compatibility issues with pulverized coal feed systems. Co-milling with sawdust had no issues, but long fibers in wood chips and hog fuel tended to plug the feed system. They are considering additional tests with very small chips. The use of wood chips may not be a problem with feed systems that do not pulverize the coal.

Another example of co-firing is Santee Cooper, South Carolina's state-owned utility. They first used co-firing with 10% wood after Hurricane Hugo in 1989 damaged 4.4 million acres of timber in their state. They now have an agreement with the U.S. Forest Service to purchase wood from tree-thinning projects to restore forest health, improve habitat, and reduce wildfire risk.[28]

The US Forest Service Rocky Mountain Region and State & Private Forestry purchased the first forest biomass-based Renewable Energy Certificates (RECs) sold on the voluntary market. Using co-firing, Aquila's W.N. Clark Generating Station in Canon City, Colorado produced 730 Megawatt-hours (MWh) of electricity using biomass.[29]

Opportunities for Biofuels

One of the best energy systems is the tree. In addition to the energy potential already mentioned, it can be made into myriad fuels and chemicals. Through enzymes or fermentation it can produce ethanol to fuel cars and trucks. Through the processes of gasification and pyrolysis (heating biomass in oxygen controlled conditions), biomass can produce syngas, methanol, pyrolysis or bio- oil, diesel fuel, and an array of chemical feedstocks (organic acids, glycerine, cellulose polymers, etc.) and materials (foams, plastics, lubricants, adhesives, paints, solvents, inks, etc.) for industry.

The U.S. dependence on oil has resulted in the transfer of $1.16 trillion to oil-producing countries over the last three decades, and this wealth transfer is expected to continue.[30] Using biomass delivers a tri-fold benefit: it keeps the wealth nearby, it pays rural growers for the production of biomass feedstocks, and it provides clean energy.

Biofuels are essentially non-toxic and biodegrade easily. Currently, ethanol is most often made from the starches and sugars of plants, which is only a small portion of the biomass available. The bulk of most plant materials are the cellulose and hemicellulose, and making ethanol from these expands the types and available feedstocks. Biodiesel is frequently made from soybeans at present. Using the Fischer-Tropsch method, which converts hydrogen and carbon monoxide into liquid hydrocarbons, diesel fuel could be made from woody biomass.

The Department of Defense recognized that relying on foreign sources of oil increases risk to our military forces. In 2005, the Department of Defense teamed with the Department of Energy in announcing the Clean Fuel Initiative to produce various fuels from sources including biomass using Fischer-Tropsch technology. In addition to the Clean Fuels Initiative, the U.S. Air Force, which currently spends about $5 billion per year on aviation fuel, is examining alternatives to petroleum-based jet fuel. Nearly 75% of the military fuel consumption is in the form of jet fuels, followed by ground fuels then marine fuels.[31]

ADDITIONAL OPPORTUNITIES and BARRIERS

Converting existing boilers to wood burning boilers represents several types of potential opportunities and barriers. The commercialization section of this report discusses the opportunities and barriers associated with finances and market size. This section presents a selection of additional issues that could represent potential opportunities or potential barriers to large-scale boiler conversion.

Government and Market Drivers

The Healthy Forest Restoration Act (2003) and associated stewardship contracting is intended to result in the thinning of thousands of acres of forest, generating large quantities of woody biomass. Much of this biomass is expected to be of low value, requiring some form of disposal. Large-scale boiler conversions have the potential to provide a steady, long-term demand for this material, creating a win-win situation for forest managers and boiler owners.

The Energy Policy Act of 2005 contains a number of provisions and incentives to advance bio-fuels, bio-power, and bio-based products used in the U.S., and improve the industrial biotechnology used in their production. The funds to carry out the purposes of the ACT are only authorized at this point. If the funds are appropriated, they should be available by 2007. The 2002 Farm Bill supports this Act by including incentives for the removal and beneficial use of excess woody biomass.

There are two identical bills,[32] one in the House of Representatives and one in the Senate, recently introduced before the US Congress. Known as the Renewable Schools Energy Act of 2006, the bills propose amending the Internal Revenue Code of 1986 to allow public school districts to receive no-interest loans for the purchase of renewable energy systems. Based upon population percentage growth rates, the states that would qualify include Nevada, Utah, Arizona, Montana, Colorado, and Idaho.

These drivers are reflected in the formation of the USDA Forest Service Woody Biomass Utilization Team, designed "to promote and facilitate the planning and delivery of an integrated, interdisciplinary approach to the recovery and utilization of woody biomass from ecological restoration and hazardous fuels reduction work as a result of the National Fire Plan's 10-year Comprehensive Strategy, the Healthy Forests Initiative, and the Healthy Forests Restoration Act."[33]

Other potential government drivers for boiler conversions to wood-based fuel include those programs related to renewable energy, homeland security, energy independence, distributed energy (avoidance of massive blackouts), carbon sequestration, rural development, economic development, and pollution prevention.

Woody Biomass Policy and Institutional Framework

Some of the national and regional laws and initiatives in support of the use of woody biomass are listed below.

- Energy Policy Act of 2005
- Biomass Research and Development Act of 2000
- Farm Bill of 2002, Section on Rural Renewable Energy
- National Fire Plan of 2000 & 10-year Comprehensive Strategy
- President's Healthy Forest Initiative of 2002
- DOE/DOI/USDA Memorandum of Understanding on Woody Biomass Utilization
- Healthy Forest Restoration Act of 2003
- Federal Woody Biomass Utilization Workgroup (DOE; DOI- BLM, BIA, NPS; USDA-FS, RDU, NRCS, CSREES)
- Western Governors' Association Biomass Task Force Report
- Western Governors' Association Policy Resolutions:
  - 04-14 Clean and Diversified Energy Initiative for the West
  - 03-19 Western States' Energy Policy Roadmap
  - 03-18 Improving Forest and Rangeland Ecosystem Health in the West
  - 05-18 Future Management of the National Forest and Public Lands

Utah Renewable Energy Incentives

Utah announced plans to improve the state's energy efficiency by 20 percent by the year 2015. This goal is expected to be met five years sooner than the challenge issued by the Western Governors' Association to improve energy efficiency in the West by 2020. Part of the policy includes installation of on-site renewable energy sources.[34] Governor Huntsman developed a 10-point economic development plan during his election campaign. In that plan, renewable energy was identified as a key component in growing Utah's economy with the Governor stating, "Utah should position itself as a leader in renewable energy technologies and not lose opportunities to other western states… who are pursuing this area aggressively."[35]

Utah's current incentives involving biomass are described below.[36]

<u>Income Tax Credit</u> - Utah offers a state income tax credit for renewable energy systems. The credit for residential systems is 25 percent of the equipment and installation cost up to a maximum of $2,000. Commercial systems receive a 10 percent tax credit up to a maximum of $50,000. The technologies included are: solar electric, solar thermal, passive solar, wind, and hydropower. Businesses can also receive the tax credit for **biomass systems**. However, this tax credit expired on December 31, 2006.

<u>Renewable Energy Production Tax Credit</u> - provides a 1.9 cent-per-kilowatt-hour tax credit for electricity generated by wind, solar, **closed-loop biomass**, and geothermal resources (Federal incentive).

Utah Sales and Use Tax Exemption for Energy Related Equipment and Machinery - exempts the purchase or lease of equipment used to generate electricity from wind, solar, **biomass**, landfill gas, anaerobic digestion, hydroelectricity, and geothermal resources from the state sales tax. A facility is eligible if it has a generation capacity of 20 kW or greater or if it increases its generation capacity by one or more MW as a result of the machinery or equipment. Eligible purchases or leases must be made for or by a renewable energy production facility on or after July 1, 2004, and before June 30, 2009. All leases must be made for at least seven years. This exemption expires on June 30, 2009.

The renewable energy income tax credits in Utah expired at the end of 2006. During the last general legislative session, the language in the renewal bill was expanded to include more on biomass. The bill's passage was held up on the last day of the session, along with other bills associated with the proposed tax structure changes. The bill's text can be read at http://www.le.state.ut.us/~2006/bills/hbillint/hb0042s02.htm

Market Drivers

For biomass-derived fuels, power, and products to penetrate the market dominated by fossil fuels, they must be able to compete with their non-renewable counterparts in both performance and cost. One of the problems with the markets have been that the price doesn't always take into account all of the costs and benefits. For example, fossil fuels contribute to the build-up of green house gas emissions (an environmental cost), and the efficient use of biomass improves ecosystem health, reduces wildfire, and eliminates alternative disposal (an environmental benefit). However, the costs and benefits have not traditionally factored into the price of these fuels. This is a failure of the market, which needs help internalizing these external costs and benefits. Rather than the command and control method of government regulation, new, more efficient methods that utilize market forces have been developed over the years. One way is to create a separate product that captures the attributes of the positive or negative externality that can be sold or traded on the market. Thus is the basis of emission credits and renewable energy credits.

Pacificorp, doing business as Rocky Mountain Power in Utah, has the Blue Sky Program, which offers customers the opportunity to support and purchase clean energy from new renewable sources in 100 KWh increments by paying a premium over conventionally generated electric rates. The program is voluntary, and the premium price goes to pay for the purchase of "green tags" and public education and administration of the program. Pacificorp offers the Blue Sky Program in each of its 6-state coverage area, but over half of the programs sales originate from Utah. This summer, Pacificorp offered a request for proposals (RFP)[37] for the purchase of renewable energy credits (RECs) or green tags for renewable energy produced in a new Utah renewable facility to help stimulate the market for renewable energy. The Blue Sky program focuses on wind, although solar and geothermal are also approved. Biomass has not yet been adopted for this program, but may be an option for the future. The development of the "green tag" market will use market forces to provide incentives for the use of biomass.

Economic Development and Service Infrastructure

Utah's forest products industry has suffered heavy losses over the past decade. Future stability in these employment areas depends on increases and sustained availability of wood from federally controlled land through the national stewardship contracting and forest timber sale programs, which in turn hinges on wide public acceptance of Forest Service plans for thinning Utah's national forests. Large scale boiler conversion projects could help drive the demand for otherwise low-value forest thinning materials and, in doing so, help stabilize and enhance the wood products industry in Utah. Large-scale boiler conversions could also lead to the creation of new boiler-related industries that are now concentrated in the mid-western and eastern states.

Issues Related to Feedstock

The Fuels for Schools program developed, in part, from "the need to provide a safe and timely means of disposing of unmarketable small woody material that was removed from the land to reduce the risk of catastrophic forest fires."[38]

Estimates suggest that forest-thinning operations in western states could generate roughly 10 green tons/acre on a 35-year harvest cycle. (These harvest figures may be optimistic for many parts of Utah depending on area and tree species.) Assuming a wood fuel value of 10.8 million BTU/green ton, these values suggest that forest thinning operations could provide roughly 108 million BTU/acre each time it is harvested, or an average of 3 million BTU per acre as a sustainable yield. This can be compared to an estimated boiler demand of 1,250 million BTU/year per million BTU/hr boiler size.[j] Based on these values, it would take the thinning of about 12 acres per year, or a total of 400 acres total on a 35 years harvest cycle, to supply the needs of a 1 million BTU boiler. These estimates will, of course, vary significantly depending on the characteristics of the boiler and the facility it serves as well as the characteristics and harvest objectives of the forest used for supply.

The most notable limitation to woody biomass feedstock availability is that the federal government currently does not enter into long-term contracts for harvesting on National Forest lands- something usually required for financing the infrastructure to harvest and manufacture wood products. New stewardship contracting guidelines may help in this regard. Private lands make up a smaller percentage of potentially harvestable forest lands in Utah; however, it is unknown whether or not these lands are in a condition suitable to meet yields described above.

A guideline for private financing and development of a biomass power plant is that feedstock availability must be 2 to 3 times the amount necessary for sustained operations.[39] Adding this requirement suggests there would need to be 800 to 1,200 total acres of forest available to supply the fuel needed for a 1,000,000 BTU/hr boiler.

With proper forest management, woody material can be continually replenished and, therefore, has the potential to provide a sustainable and dependable feedstock supply.[40] Under these conditions, wood-fueled boilers represent a use of renewable energy. Unlike renewable energy

[j] Based on a wood boiler efficiency of 70% in a facility with a utilization factor of 0.10.

derived from wind, solar, hydropower, and geothermal resources, using wood as a source of energy has the potential to benefit the resource from which is was derived in the form of improved ecosystem health.[41]

In addition to increasing forest harvest activities, feedstock deliveries would increase truck traffic in the region, particularly in the immediate vicinity of the boiler facility. Deliveries would typically be achieved with a 25-30 ton tractor-trailer chip van with a live floor. A facility burning 500 tons of wood chips may have as many as 17-20 truckloads during a heating season (from October-April), with more frequent deliveries during the peak heating season (December-February). Like forest thinning activities, additional truck traffic created by the facility may be opposed by local organizations that may choose to take political action to restrict such activities, again representing a supply risk.

Weather conditions limit harvesting and hauling during the year, particularly during the same season that the fuel will be needed for heating. Because deliveries cannot be made year-round, the boiler facility needs storage space for wood fuel. Most existing boiler rooms are not adequately sized to allow for the installation of a wood chip boiler. Therefore, a new building is often required to house the boiler and some woodchip supply. The footprint of a biomass boiler building is approximately 30 x 50 feet in size and requires access for delivery vehicles. Some facilities have created an area where woodchips can be stockpiled. The need for storage increases capital costs and increases the impact that the facility has on local land use.

Environmental and Political Issues

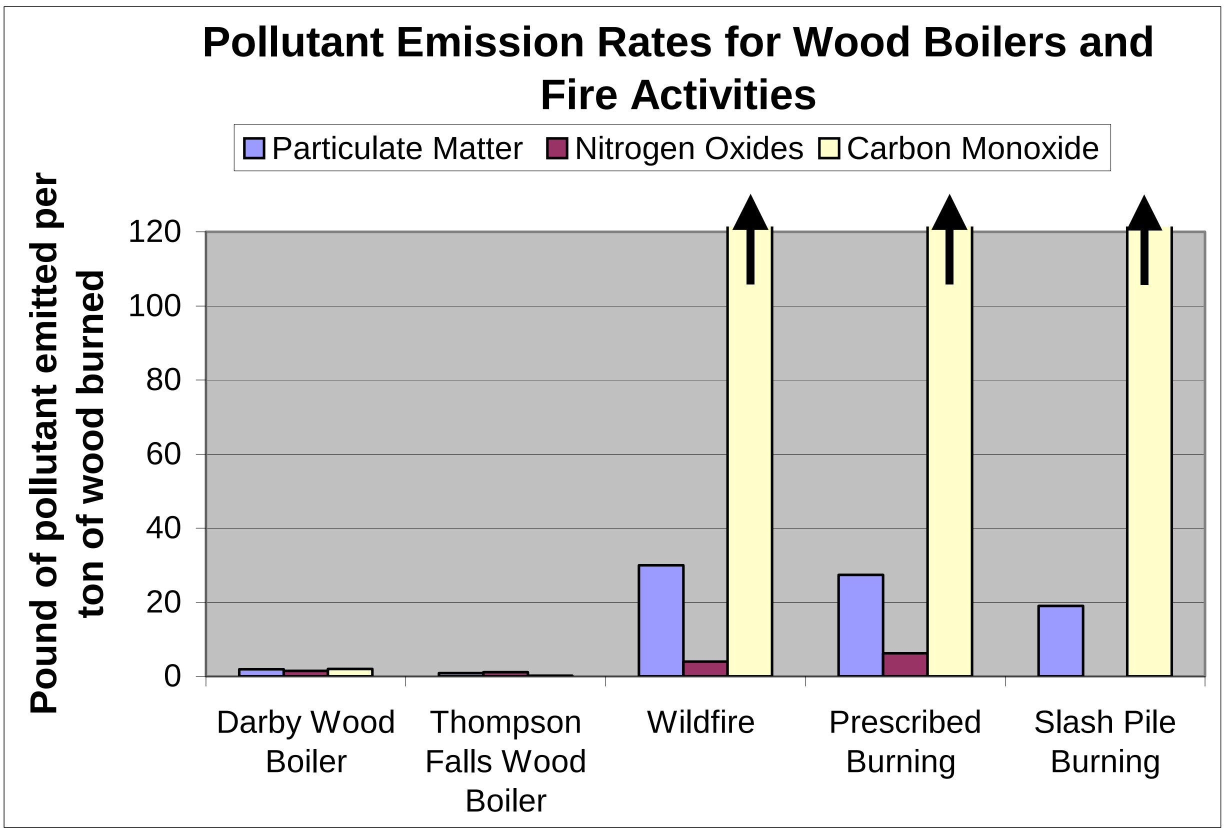
The feasibility of a given boiler conversion project will depend on resolution of a number of regulatory, permitting, and political issues. In order to be feasible, the proposed conversion project must be able to mitigate environmental impacts to the satisfaction of the regulatory agencies, citizens, communities, and other stakeholders. Regardless of perceived benefits, the potential environmental impacts of forest thinning activities will attract the concern of citizen and environmental organizations, and they may choose to take political actions to restrict such activities. The political activities that may result from real and perceived environmental impacts of forest thinning activities represent a risk to supply reliability. Investigating the full range of regulations that would need to be addressed when developing a boiler conversion project is beyond the scope of this study; however, selected issues that are likely to have to be addressed are described in this section.

Issues Related to Air Quality

Wildfires discharge huge quantities of smoke into the air. The U.S. Forest Service (USFS) reports “dense plumes of smoke (from wildfires) can be transported over hundreds of kilometers across state and international boundaries.” It also reports that “several communities in the United States have experienced particulate matter concentrations from wildfire smoke that exceeded EPA’s significant harm emergency action level of 600 ug/m^3, defined as an ‘imminent and substantial endangerment of public health’”.[42] Prescribed burning and burning of slash piles result in localized, but more frequent, generation of air pollution. During 2005 in Utah there were 840 fires that burned a total of 671,576 acres. The number of fires was higher than normal, but the number of acres burned was less than the 10-year average.[43]

One driver in the conversion of existing boilers to wood-fueled boilers is finding beneficial uses for woody biomass to help reduce the amount of air pollution caused by wildfires, prescribed burns, and burning of slash piles. Though modern boilers can be designed to burn wood very cleanly, any proposed boiler conversion project would be closely scrutinized for potential pollution discharges, particularly discharges affecting air quality. Many wood fueled boilers can meet strict emissions standards without additional controls. If required, a number of technologies are available for wood boilers to reduce particulate air emissions such as catalytic converters for combustion of unburned hydrocarbons and individual or combined methods of filtering, scrubbing, and precipitating for the treatment of exhaust gases. The technology is ever improving. Commercial and institutional-size models that utilize the concept of gasification are being readied for market, which could also improve emissions.

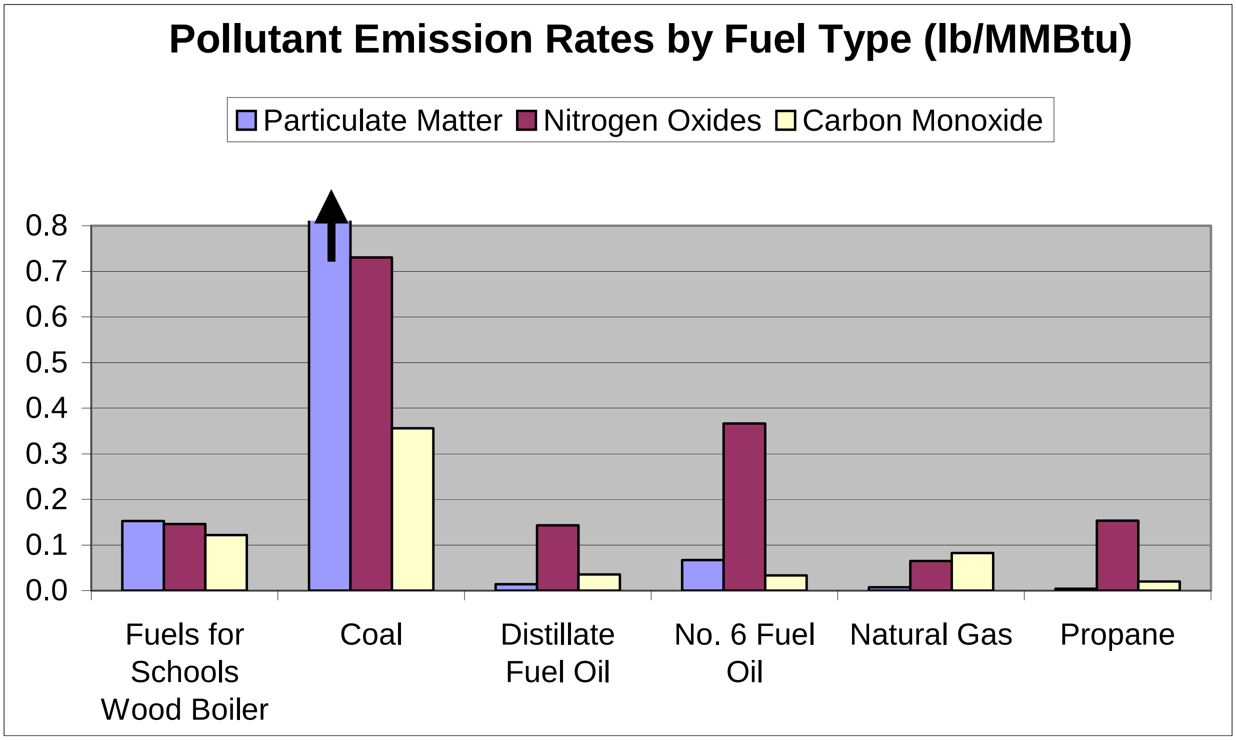
Figure 16. Comparison of Emissions from Woody Biomass Boilers and Fire Activities



Source: www.fuelsforschools.org

Figures 16 through 18 show comparisons of emissions.[44] The three most prevalent compounds emitted by a woody biomass boiler (therefore carefully tracked) are particulate matter (PM), nitrogen Oxides (NO_x), and carbon dioxide (CO_2). Figure 16 compares woody biomass boiler emissions to fire activities. Figure 17 compares emissions from various fuel sources. It is important to remember that the wood burned in a biomass boiler is not only replacing a fossil fuel type, but also eliminates an alternative disposal of the biomass, such as via wildfire. Figure 18 compares emissions from a woody biomass boiler to the more familiar wood or pellet stoves.

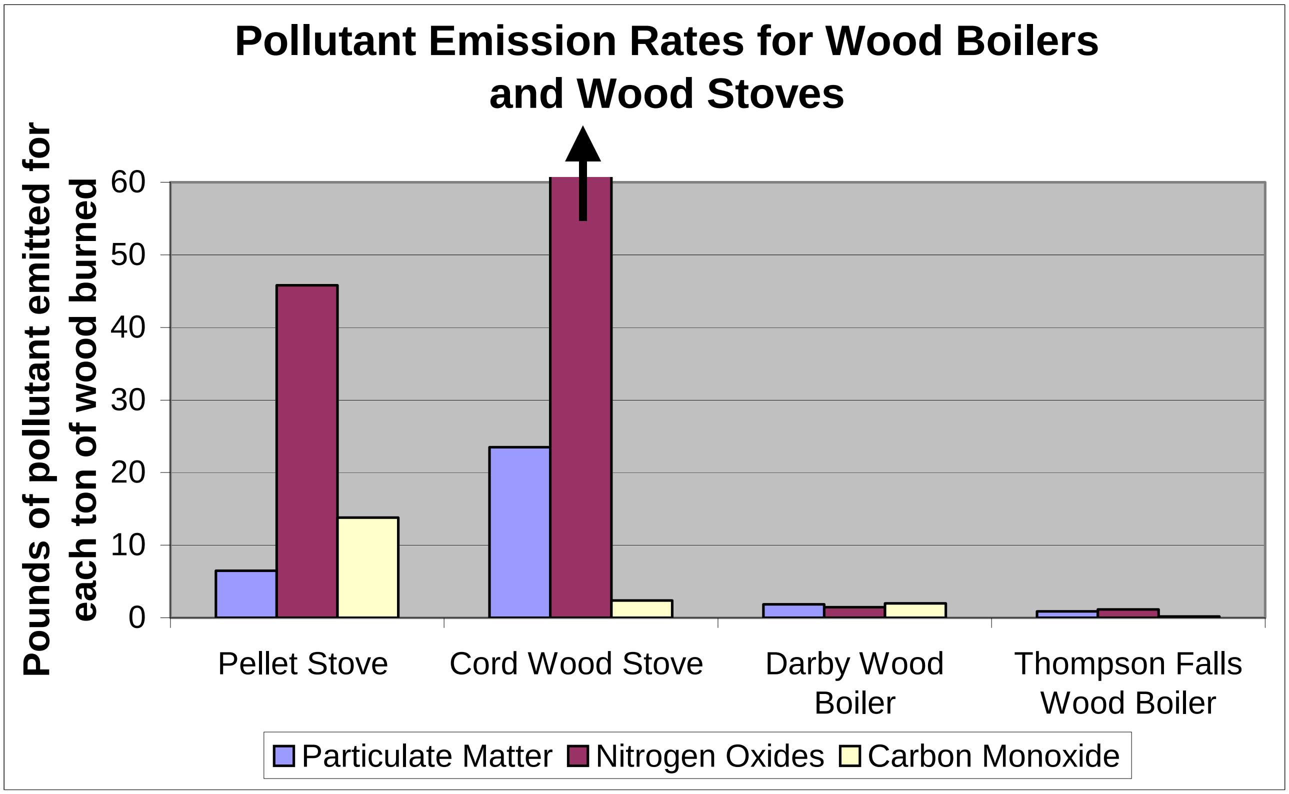
Figure 17. Emission Rates by Fuel Type



Source: www.fuelsforschools.org

For smaller boilers, conversion to using wood pellets may be more economical than converting to using wood chips as a fuel source. Pellet consistency and burn efficiency produces significantly less particulate emissions than green chipped wood.[45] An additional benefit of pellets is that materials other than wood can be used as a raw material. For example, fuel pellets are being made from such materials as agricultural wastes, animal wastes, and municipal solid wastes as well as energy crops. These options not only diversify the sources of potential raw materials for pellet manufacturing, but also provide a beneficial outlet for waste materials. Wood pellet manufacturing is very limited in Utah at this time. Although pellets are currently bagged for sale, bulk sales and delivery are possible.

Figure 18. Emission Comparisons of Woody Biomass Boilers and Wood Stoves



Source: www.fuelsforschools.org
Note: The boiler located at Darby MT School District has no additional emission controls. Thompson Falls, MT is a non-attainment area.

There are areas in Utah that experience various problems with air quality, including several areas that are listed as state or federal air quality non-attainment areas for different components. Although wood-burning boilers have the potential to reduce pollution compared to in-situ burning or compared to existing fuel burning, non-attainment status will make it more difficult and more expensive to establish a new wood burning facility that has the potential to discharge pollutants to the air. On December 18, 2006 new EPA standards that reduce allowed concentrations of PM 2.5 went into effect. The new standard is 35 micrograms per cubic meter; nearly half of the current standard of 63 micrograms per cubic meter. The counties in Utah that could fail to meet the new standards include Cache, Box Elder, Weber, Davis, Morgan, Salt Lake, Summit, Tooele, Utah and Juab.[46] Permitting a biomass facility would fall under the jurisdiction of the Utah Division of Air Quality, and the requirements are subject to change as necessary to meet federal and state requirements. Table 31 shows the current areas of non-attainment and maintenance in the state.

Table 31. Utah, NAAQS Areas of Non-attainment and Maintenance

Sulfur Dioxide (SO2)	Particulate (PM10)	Ozone (O3)	Carbon Monoxide (CO)
Salt Lake County Non-Attainment Area	Ogden City Non-Attainment Area	Davis County Maintenance Area	Ogden City Maintenance Area
Includes East Tooele County above 5,600 feet	Salt Lake County Non-Attainment Area	Salt Lake County Maintenance Area	Salt Lake City Maintenance Area
	Utah County Non-Attainment Area		Provo/Orem Maintenance Area

National Ambience Air Quality Standards, updated by DEQ July 2006
Source: Utah Division of Air Quality [47]

In addition to local air quality issues, Regional Haze Laws affect several western states, including Utah. Utah was the first state to have a regional haze plan approved in 2003 with another state implementation plan (SIP) update due in 2007.[48] It is not yet clear what these laws will mean for a wood-burning facility because none were active in the state when the report was first written. The state has adopted emissions standards for smoke management[49] that put limitations on prescribed burn and slash pile burning and encourage non-burning alternatives to fire. This could be beneficial for feedstock availability.

Renewable Energy in Utah

Part of the recommendations from the SIP includes renewable energy generation goals for the region. As part of the information requirement for pollution prevention, the State Energy Program[50] provided Utah's most recent year's available data for renewable energy consumption by user class and source (Table 32) and renewable energy generation by source (Table 33). As can be seen in Table 32, residential, commercial, and industrial users use wood for energy. However, Table 33 shows that in Utah, renewable energy is less than 1% of the total energy consumed in the state, and the amount of wood used for energy is negligible. At a national level, renewable energy makes up 6% of the energy portfolio with a third of that coming from wood.[51]

Table 32. Renewable Energy Consumption in Utah, 2003

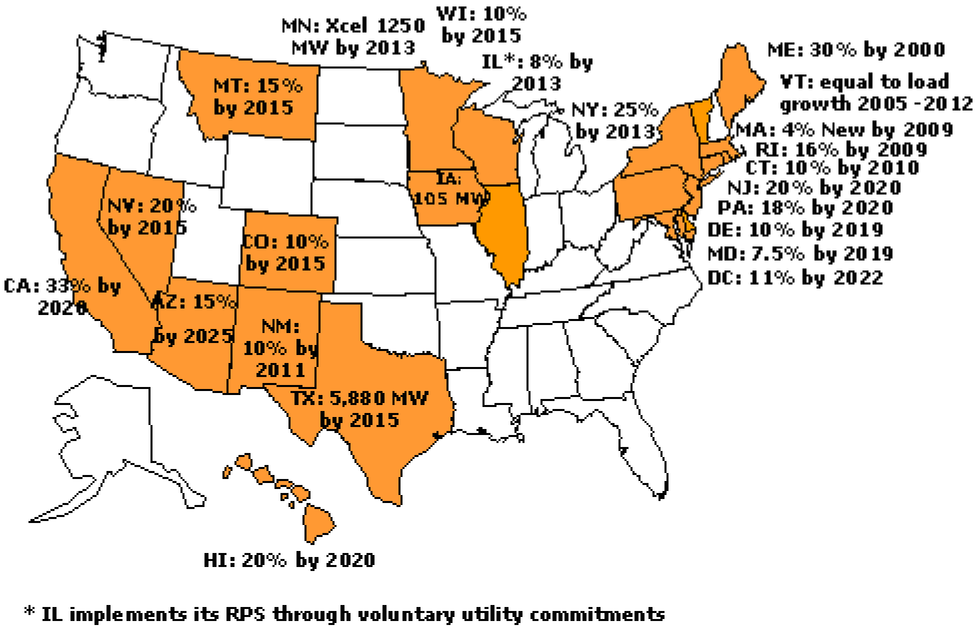
User Class	Source	Units	Amount
Residential	**Wood**	Thousand Cords	106.1
		Billion Btu	2,121.8
	Direct-use Geothermal	Billion Btu	30.6
	Solar-Residential and Commercial	Billion Btu	43.4
Commercial	**Wood and Waste**	Billion Btu	372.6
	Direct-use Geothermal	Billion Btu	222.4
Industrial	**Wood**	Billion Btu	132.8
	Waste	Billion Btu	73.3
	Geothermal	Billion Btu	284.1
	Hydroelectric	GWh	0
		Billion Btu	0
Electric Utility-Net Generation	**Waste**	Billion Btu	1,297.0
	Geothermal	MWh	198.5
		Billion Btu	3,964.4
	Hydroelectric	GWh	421.3
		Billion Btu	4,314.9
Transportation	**Ethanol**	Thousand Barrels	76.6
		Billion Btu	271.0

Table 33. Total Renewable Net Generation (Megawatt hours) by Source in Utah, 2003

Geothermal		198,465
Conventional Hydroelectric		421,339
Biomass	**Wood/Wood Waste**	-
	MSW/Landfill Gas	9,241
	Other	-
Solar		-
Wind		-
Total Renewable Generation		629,045
Total State Generation		38,023,666
Percent Renewable		1.7%
State Rank by % Renewable		39
Percent Renewable (Excluding Hydroelectric)		0.5%

A number of states have adopted Renewable Energy Portfolio Standards (RPS), which requires a certain percent of a utility's power plant generation or capacity to come from renewable sources by a certain date. Figure 19 shows a map of states in the nation with renewable portfolio standards.

Figure 19. States with Renewable Portfolio Standards as of May 2006.



Source: Pew Center on Global Climate Change[52]

While the current situation in the State of Utah is that renewable energy is less than the national average (with wood being a negligible part of that energy), the situation could dramatically change in the future. Should Utah choose to adopt a Renewable Energy Portfolio Standard like many of her neighboring states, woody biomass could make a much more significant contribution towards meeting renewable energy goals within the state. There are other states that purchase electricity generated in Utah using coal. As those states adopt/enforce renewable portfolio standards, there will be greater pressure to use more renewable energy sources.

Facility-Specific Issues

The previous section of this report presented economic issues related to boiler conversion; however, there are numerous other factors that might affect the potential likelihood of converting a boiler system at a particular facility. Some considerations are listed below.

Boiler conversions are more feasible for the following situations:

- Facilities with a high and sustained demand for fuel for heating, cooling, domestic hot water and/or power. Not only will the boiler run more efficiently but the upfront capital costs will be paid back sooner through annual fuel cost savings.

- Facilities located near other biomass boiler systems. There will be economies of scale for suppliers. Serving several clients will strengthen the suppliers' business portfolio and minimize transportation distances between delivery areas.
- Facilities located near wood waste producers (for example: log home builders, post and pole mills, and other mills). Transportation distance and costs are minimized.
- Facilities that have significant forested acres under their control. Some facilities have the resources available to grow their own energy source.
- Facilities located in areas without access to natural gas. They are more likely to be using a more expensive heating source.
- Facilities located in rural areas. These areas are more likely to benefit from increased economic development and be closer to forested areas and forest products industry
- Facilities that could utilize urban tree waste or clean construction waste. This will provide supply in a more urban setting and diversify the supply stream.
- Facilities that could burn pellets.
- Facilities willing to lead the market and be a demonstration site.

Boiler conversions are less feasible for the following situations:

- Facilities with intermittent heating demands and high peak loads.
- Facilities with electric base board heat or numerous heat sources. The cost of mechanical integration would likely be prohibitive.
- Facilities lacking access to the boiler room.
- Facilities requiring significant buried pipe between biomass boiler building and existing system. The expense of the piping could add significantly to the project cost.
- Facilities with energy efficient building envelopes that consume very little heat energy. While admirable, the annual fuel cost savings would be minimal.
- Facilities with significant space constraints. This would limit their ability to store supply and/or allow chip trucks to safely make deliveries.

STRATEGIC RECOMMENDATIONS[k]

The Utah Division of Forestry, Fire & State Lands and the US Forest Service are interested in assisting the development of viable commercial uses of woody materials removed from our forests for forest health and hazardous fuel reduction. The Fuels for Schools and Beyond program is in the demonstration phase of a 3-phase USFS initiative to promote and encourage the use of wood biomass as a renewable, natural resource to provide a clean, readily available energy source suitable for use in heating systems in public and private buildings. The next phase of this initiative involves expanding this concept and transitioning towards commercialization.

Successful transition of the Fuels for Schools and Beyond program to commercialization will depend on the development of a *business ecosystem*[l] that encompasses USFS goals for forest thinning operations and market incentives for conversion to wood-fueled boilers. A complete shift to commercialization requires market-driven economics that support investment in boiler conversion from both the consumer and the vendor perspectives.

The findings of this study indicate the need to pursue several activities to further efforts towards commercialization of the Fuels for Schools concept:

- Engage key stakeholders
- Assess woody biomass supply viability
- Explore additional partnerships, drivers, and opportunities
- Disseminate information
- Establish a demonstration project in Utah

Engage Key Stakeholders In Next Steps

The Utah Division of Forestry, Fire & State Lands in partnership with the USFS and WGA should engage key stakeholders within the potential wood-fired boiler business ecosystem to highlight the areas where USFS should focus future efforts in facilitating commercialization.

Information about the program needs to be shared with facility owners from among the groups of boilers considered to be strong candidates for conversion. Then efforts should continue by engaging boiler manufacturers (with a focus on smaller boilers), wood suppliers, processors, and distributors (loggers, haulers, mills, etc.), and pellet manufacturers.

[k] This report segment, as well as general portions of the previous segment regarding barriers and drivers, was taken from the Montana Boiler Assessment, 2004 by CTA et. al. Being applicable to all the states in the program region, it was reproduced in this report.

[l] A *business ecosystem* is a community of organizations and stakeholders (players) operating within a particular business environment, which collaborate and compete in an economic web of relationships. These relationships co-evolve through time subject to the general forces in the business environment and the specific moves made by the web of players.

Information generated to date suggests that wood-fired boilers can be viable in some applications and that there could be a potential commercial market for boiler conversions and replacements. Refining this general information will require input from the stakeholder groups that would have to take financial risks to make commercialization happen. Such discussion might focus on issues related to business expansion requirements, retooling requirements, financing issues, fuel costs and availability, site logistics and boiler parameters, etc. The resulting information would further clarify the potential size, scope, and viability of the market for wood-fueled boilers.

Assess Wood Supply Viability

Forestry, Fire & State Lands should identify and evaluate existing sources of woody biomass such as wood waste from existing manufacturers, hazardous fuel reduction projects, clean construction waste, urban forest waste, and forest harvesting projects within selected distances of boilers or boiler clusters.

The strategic recommendation is to develop a new renewable energy production and distribution system. Currently, woody biomass is generally viewed as a disposal problem that is either burned or hauled to landfills. The challenge is to develop demand for the material around which an energy production/distribution business can be built. Specific actions needed include:

- Establish a demonstration site to showcase a successful operation;
- Select a project site near some existing sources of woody biomass to facilitate supply of fuel;
- Select a facility or combination of facilities with woody biomass demand large enough to establish or sustain a supply business;
- Work with the multitude of potential sources listed above to establish contracts for supplying material over time;
- Form a state-wide working group of state, federal, and local government representatives working with the private sector to facilitate the development of this system.

Successful large-scale boilers conversions will require a long-term supply of woody biomass fuel that is economically and environmentally viable. Although the goal of the Fuels for Schools program is to find viable commercial uses of woody materials removed for hazardous fuel reduction, to date, accessing that wood supply has been challenging and represents an investment risk. The attraction of annual fuel savings in boiler conversion could be nullified by a perception of risk in the wood fuel supply. For example, financial institutions may require a secure fuel supply for a defined period of time. If wood is to compete with natural gas, fuel oil, coal, and electricity, there must be some assurances that changes in forest management policy will not endanger the reliable long-term fuel supply that would secure a boiler conversion investment. A strong emphasis on long-term stewardship contracting may help to alleviate these concerns. As shown in the earlier section of this report focused on biomass supply in the state, there is sufficient woody biomass supply in Utah. The challenge is to connect people, agencies, and businesses together to make the material available and get it delivered to those who want it. The Division of Forestry, Fire & State Lands is the agency in the state that could facilitate that connectivity.

Explore Additional Partnerships, Drivers, And Opportunities

Forestry, Fire, & State Lands in partnership with the US Forest Service should also explore the potential for partnering with other interests that may have additional unique drivers and opportunities that could leverage steps towards commercialization. Such potential partners might include:

- Bureau of Land Management
- USDA Rural Development
- Associations of Government
- Natural Resource Conservation Service (NRCS) and Resource Conservation and Development (RC&D) Councils
- Utah Forest Products Association
- American Institute of Architects (AIA)
- American Society of Mechanical Engineers (ASME)
- School and Institutional Trust Lands (SITLA)
- Local Economic Development Agencies
- The Pellet Fuels Institute (PFI)
- Intermountain Combined Heat and Power
- The American Boiler Manufacturers Association (ABMA)
- U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy (EERE) program and National Renewable Energy Lab (NREL)
- The Energy Services Coalition (ESC). ESC is a national nonprofit organization composed of a network of experts from a wide range of organizations working together at the state and local level to increase energy efficiency and building upgrades through energy savings performance contracting. Energy savings performance contracting enables building owners to use future energy savings to pay for up-front costs of energy-saving projects, eliminating the need to dip into capital budgets. ESC provides its members with many resources to facilitate performance contracting projects, energy efficiency improvements, and building upgrades. [53]
- Energy Service Companies (ESCO). Energy Services Companies (ESCOs) offer performance contracting services that can identify and evaluate energy-saving opportunities and then recommend a package of improvements to be paid for through savings. The ESCO will guarantee that savings meet or exceed annual payments to cover all project costs—usually over a contract term of seven to 10 years. If savings don't materialize, the ESCO pays the difference, not the consumer. To ensure savings, the ESCO offers staff training and long-term maintenance services. ESCOs typically:
    - Identify and evaluate energy-saving opportunities;
    - Develop engineering designs and specifications;
    - Manage the project from design to installation to monitoring;
    - Arrange for financing;
    - Train your staff and provide ongoing maintenance services; and
    - Guarantee that savings will cover all project costs.[53]

- Other states' programs. For example, the State of Vermont's Department of Public Service (DPS) and the Department of Forests, Parks and Recreation (FPR) are national leaders in the research, development, and commercialization of wood energy. In particular, they focus on clean combustion of wood chips for heat and electricity production.

Disseminate Information

Currently, there appears to be a general lack of awareness among most facility owners, engineers, and architects that modern wood-fired boiler systems are an available option and that they could reduce facility fuel costs. A proactive effort to share this information among partners identified above would be an important step towards commercialization. There are also a number of misperceptions that have been perpetuated over the years regarding supply, forest management techniques, and emissions from wood combustion that open dialogue and education can attempt to correct. Having a successful biomass demonstration project in the area could alleviate a lot of apprehension on the part of potential users.

APPENDIX

Initial Identification of Potential Boilers for Conversion

The first part of the Appendix focuses on boilers that, at first blush, would be potential candidates for conversion to biomass. Figure 20 shows a map of Utah divided into counties with the number of active boilers in each county. The same data is also found in Table 34 where the counties are ranked by the numbers of boilers. The data was included because it is logical to assume that there are more possibilities for boiler conversion in areas that have more boilers. The number of boilers in an area tends to be correlated with the population. Unfortunately, the likelihood of air quality problems that might raise emission concerns and increase costs for conversion is also positively correlated with population.

Because wood is one of the lowest cost fuels, is it logical to look for conversion potential among boilers that use the highest priced fuel, which is electricity. Table 35 shows the electric boilers in the state ranked by size. Only those above 500,000 Btu per hour are listed.

While it is unknown how long a particular boiler may be functional, the average life span is considered to be around 30 years. It is likely that boilers older than that will be targets of replacement. The boiler database listed a number of boilers that were well beyond that age. Table 36 lists the boilers in each county that are over 60 years old.

A biomass boiler will be able to pay back its capital costs more quickly if it uses more fuel. Based on location and ownership, the boilers in the database were assigned a facility utilization factor. Those facilities likely to have the highest facility utilization factors include hospitals, correctional facilities, and university dormitories. Table 37 lists the numbers of boilers within each county with high facility utilization factors.

Following these tables and figure are the assumptions used in the calculations, along with other tables that are introduced later.

Figure 20. Number of Active Boilers by County

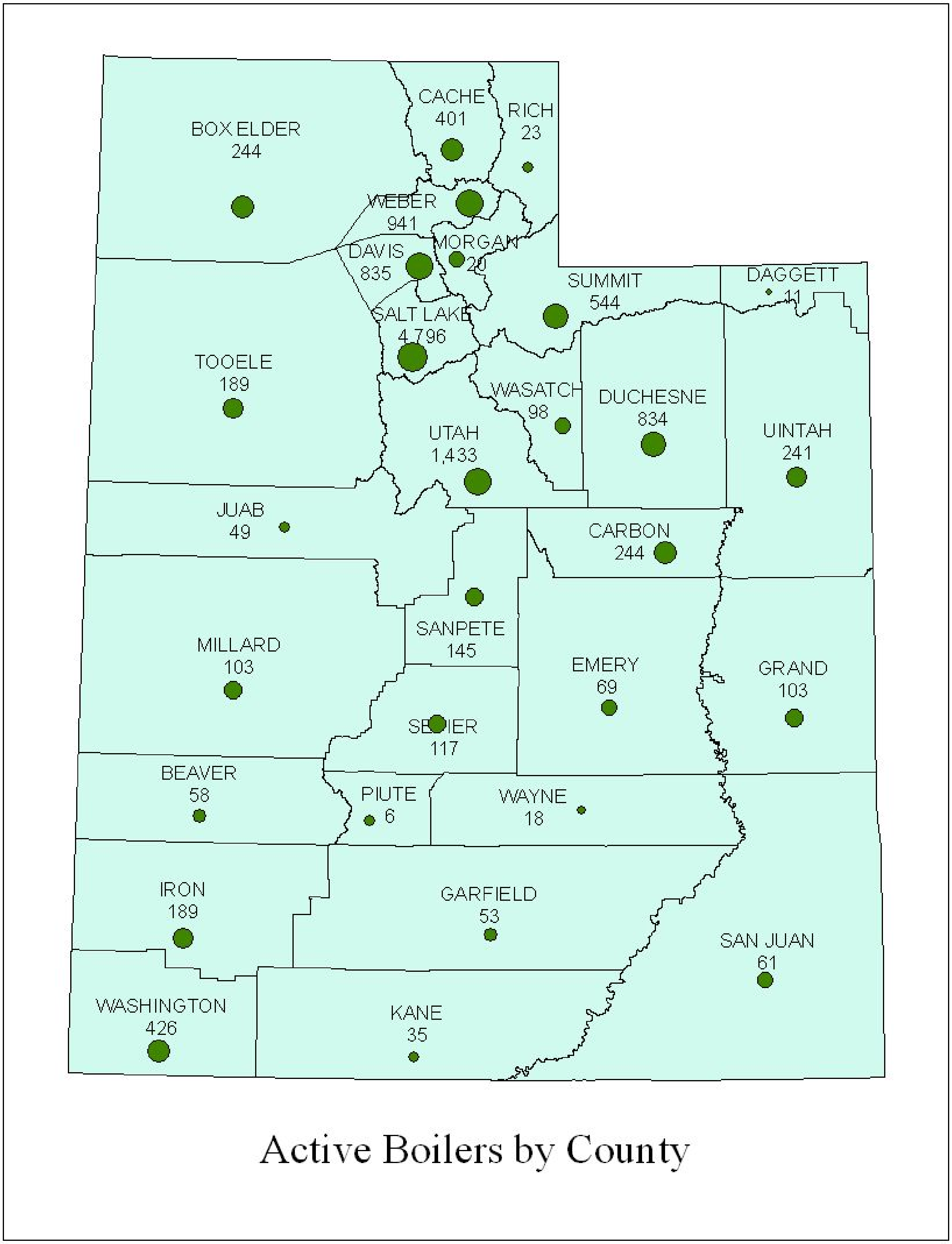


Table 34. Rank Of Counties Based On Number Of Active Boilers

Rank	County	Number of Boilers
1	Salt Lake	4,796
2	Utah	1,433
3	Weber	941
4	Davis	835
5	Duchesne	834
6	Summit	544
7	Washington	426
8	Cache	401
9	Box Elder	244
10	Carbon	244
11	Uintah	241
12	Iron	189
13	Tooele	189
14	Sanpete	145
15	Sevier	117
16	Grand	103
17	Millard	103
18	Wasatch	98
19	Emery	69
20	San Juan	61
21	Beaver	58
22	Garfield	53
23	Juab	49
24	Kane	35
25	Rich	23
26	Morgan	20
27	Wayne	18
28	Daggett	11
29	Piute	6

Table 35. Electric Boilers, Ranked by Size (greater than 500,000 btu/hr)

SIZE (BTU/hr)	FACILITY	BOILER AGE IN 2005	CITY
42,000,000	Western Zirconium	17	Ogden
5,815,000	Kanesville Elementary	28	Kanesville
5,250,000	J C Penny Company	38	Salt Lake City
4,536,000	Intermountain Power Project	21	Delta
4,536,000	Intermountain Power Project	21	Delta
3,500,000	Pacificorp	31	Salt Lake City
3,483,300	Delta Airlines GSE	16	Salt Lake City
2,750,000	Intermountain Power Project	21	Delta
2,625,000	Pacificorp	17	Salt Lake City
2,526,000	A T K - Promontory	15	Promontory
1,706,000	Intermountain Power Project	21	Delta
1,554,000	Intermountain Power Project	22	Delta
1,530,000	Pacificorp	12	Huntington
1,475,280	Sandridge Jr High	36	Roy
1,475,280	Sandridge Jr High	36	Roy
1,473,984	Deseret Power Electric Cooperative	24	Vernal
1,443,000	Intermountain Power Project	21	Delta
1,365,000	Deseret Generation and Transmission	23	Bonanza
1,312,000	Intermountain Power Project	21	Delta
1,155,000	IHC - Dixie Regional Medical Center, 400 East	22	St George
1,134,000	Monument Valley High School	23	Monument Valley
1,134,000	Monument Valley High School	23	Monument Valley
1,050,000	Utah Wood Preservatives	6	Woods Cross
945,000	Wendover Econo Lodge	24	Wendover
928,000	Jordan Commons	7	Sandy
875,000	Pacificorp	18	Salt Lake City
840,000	Dixie College	22	St George
756,000	Wendover Econo Lodge	24	Wendover
735,000	Mona Elementary	22	Mona
735,000	Sinclair Oil Corp., - Snowbasin	4	Huntsville
630,000	Sandridge Jr High	36	Roy
630,000	Sandridge Jr High	36	Roy
630,000	Intermountain Power Project	20	Delta
630,000	Intermountain Power Project	20	Delta
630,000	University Of Utah - Huntsman	7	Salt Lake City
630,000	Cache Valley Specialty Hospital	2	Logan
614,160	IHC - Dixie Regional Medical Center, 400 East	5	St George
600,000	Prime Hotel	15	Salt Lake City

595,000	Men's Warehouse	10	Salt Lake City
574,000	Tooele Jr High School	41	Tooele
570,000	University of Utah	8	Salt Lake City
562,980	Jordan Commons	7	Sandy
540,000	University of Utah	8	Salt Lake City
525,000	First Health	25	West Valley City
525,000	Mr Mac - New Gate Mall	25	Ogden
512,000	Snowbird Corporation	18	Snowbird
500,000	Intrepid Wendover Potash L L C	17	Wendover

Table 36. Boilers Over 60 Years Old, Ranked by County

COUNTY	Number of Boilers	Smallest (BTU/hr)	Largest (BTU/hr)	Average Size (BTU/hr)	Sum of Sizes (BTU/hr)
Salt Lake	70	200,000	350,000,000	18,341,186	1,283,883,000
Utah	14	250,000	8,576,000	3,483,357	48,767,000
Cache	13	200,000	3,360,000	900,923	11,712,000
Weber	11	210,000	22,400,000	3,267,091	35,960,000
Sevier	9	240,000	11,432,000	2,649,444	23,845,000
Box Elder	6	200,000	1,030,000	450,833	2,705,000
Sanpete	3	500,000	25,000,000	1,805,500	3,611,000
Tooele	3	1,115,000	3,000,000	2,371,667	7,115,000
Duchesne	2	400,000	500,000	450,000	900,000
San Juan	2	1,703,000	1,908,000	1,805,500	3,611,000
Carbon	1	1,953,000	1,953,000	1,953,000	1,953,000
Davis	1	202,500	202,500	202,500	202,500
Iron	1	250,000	250,000	250,000	250,000
Beaver	0				
Daggett	0				
Emery	0				
Garfield	0				
Grand	0				
Juab	0				
Kane	0				
Millard	0				
Morgan	0				
Piute	0				
Rich	0				
Summit	0				
Uintah	0				
Wasatch	0				
Washington	0				
Wayne	0				

Table 37. Counties With Boilers Located In Facilities With Anticipated High Utilization Rates

County	Number of Boilers	Sum of Sizes (BTU/hr)	Oldest	Newest	Avg Age
Salt Lake	317	1,160,579,298	54	1	12
Utah	84	823,049,500	49	1	16
Weber	70	40,576,100	53	2	16
Davis	47	100,814,590	44	1	16
Cache	44	350,366,400	40	2	11
Washington	35	79,210,160	22	1	7
Iron	28	155,957,000	35	1	11
Sanpete	24	89,247,000	40	3	15
Box Elder	20	19,268,499	30	1	13
Carbon	19	67,356,000	29	1	12
Beaver	11	7,779,000	41	3	10
Millard	8	5,793,000	21	2	10
Tooele	8	26,220,000	53	5	12
Duchesne	6	20,020,000	39	1	23
Kane	5	3,985,000	9	8	9
Juab	4	13,306,000	5	5	5
Wasatch	4	10,443,000	6	6	6
Emery	3	1,851,000	22	8	14
Garfield	3	609,000	30	1	12
Uintah	3	9,528,000	26	12	21
Sevier	2	462,000	9	6	8
Grand	1	1,670,000	8	8	8
Daggett	0				
Morgan	0				
Piute	0				
Rich	0				
San Juan	0				
Summit	0				
Wayne	0				

Assumptions used for Payback Calculations

Assumed Input Variables

Table 38. Assumed Facility Utilization Factors (FUFs) For Each Facility Type
(Source: CTA et al., Montana Boiler Assessment, 2004)

Facility Utilization Factors (FUF)	Facility Type
0.15	Assisted Living/Rest Homes
0.15	Hospital
0.15	Corrections/Prisons
0.15	University Housing or Heat Plant
0.08	K-12 School
0.08	Higher Education (other than above)
0.08	Private or Unknown
0.08	Government
0.03	Church/ Public Assembly
0.03	**Low**
0.08	**Medium**
0.15	**High**

Table 39. Assumed Boiler Efficiencies And Fuel Costs For Each Fuel Source

Fuel Source	boiler efficiency	fuel cost ($/unit)	fuel value (BTU/ unit)	fuel cost ($/mm BTU)
Wood	0.70	$40/ton	10,800,000	$4
Gas	0.80	$10/decatherm	1,000,000	$10
Electric	0.98	$.07 kwh	3,412	$21
Propane	0.78	$1.50/gallon	90,502	$17
Oil	0.80	$2.25/gallon	138,690	$16
Coal	0.75	$40/ton	23,100,000	$2
Pellets	0.80	$130/ton	16,400,000	$8

Prices for the various fuels, particularly petroleum-based fuels, can be subject to significant fluctuation. Wood chip prices tend to be fairly stable and have tended to increase at the inflation rate. However, last winter many consumers purchased pellet stoves for their homes to avoid higher fossil fuel heating costs. Existing production capacity was exceeded resulting in significant wood pellet price increases. The above figures are based on data from the Energy Information Administration regarding prices for the State of Utah and may not reflect prices paid according to terms of any individual contractual agreements between purchasers and fuel suppliers. The prices above are from the high end of the range for wood and the low end for the other fuels so that results will not unduly favor wood.

Assumed New Boiler System Cost By Boiler Size Range (Total Installed Cost)

The costs for wood-fueled boilers were taken from "Wood Fueled Boiler Financial Feasibility"[54] with numbers extrapolated outside the ranges provided. The cost figures showed that the $ per btu of boiler capacity generally decreased as the boiler size increased. Those "rough estimates" were for the wood system only. The author then looked at the systems installed in the Fuels for Schools and Beyond program region to establish some average costs for construction of a boiler/fuel storage facility, mechanical integration, and permits, fees, etc. These were then added onto the boiler costs to arrive at a total project estimated cost. According to the Forest Products Lab[55] and confirmed by phone call to a local boiler distributor, wood biomass energy systems are generally 50% greater than that of a fossil fuel system. As a comparison, gas boiler prices were estimated at about half of the wood boiler costs, again with a declining coefficient of boiler capacity. These boiler and project costs were very rough estimates. And since the payback periods calculated rely heavily upon those rough estimates, the reader is warned that these numbers should NOT be used to determine actual feasibility. Any site considering conversion needs to have a complete feasibility study done for that specific site to determine more accurate numbers. Another beneficial tool that was beyond the scope of this study, but recommended, is life cycle costing analysis.

Equations used to Calculate Paybacks (Source: CTA et al., Montana Boiler Assessment, 2004)

Fuel required by a wood-fueled boiler, mm BTU/yr =
(boiler size, BTU/hr)/(wood boiler efficiency)*(8,760 hrs/yr)*(FUF)/(1,000,000)

Existing Annual Fuel Cost, $/yr =
(Fuel req'd for wood boiler, mm BTU/yr)*(wood boiler effcy)/(existing boiler effcy)*(existing fuel cost, $/mm BTU)

Wood Fuel Cost, $/yr =
(Fuel req'd for wood boiler, mm BTU/yr)*(wood fuel cost, $/mm BTU)

Annual Fuel Savings with wood fueled boiler, $/yr =
(Existing Annual Fuel Cost, $/yr) – (Wood Fuel Cost, $/yr)

New Wood Boiler Cost, $ =
(boiler size, BTU/hr)/(1,000,000)*(new wood boiler system cost, $)

New Gas Boiler Cost, $ =
(boiler size, BTU/hr)/(1,000,000)*(new gas boiler system cost, $)

Extra Cost for Wood Boiler, $ =
(New Wood Boiler Cost, $) – (New Gas Boiler Cost, $)

Payback if boiler replacement required, yrs =
(Extra Cost for Wood Boiler, $)/(Annual Fuel Savings with wood fueled boiler, $/yr)

Payback if boiler replacement not necessary, yrs =
(New Wood Boiler Cost, $)/(Annual Fuel Savings with wood fueled boiler, $/yr)

Numbers Of Boilers Within Selected Payback Ranges

There are a total of 12,308 active boilers listed in the State's boiler certificate database. Complete or accurate data were not available for all boilers, so several sets of boilers were eliminated from the database before computing payback periods. Boilers eliminated from calculations include:

- boilers (39 boilers) with missing data required in the payback period calculations
- boilers with coal listed as existing fuel source (118 boilers), because using coal as a fuel is currently cheaper than wood, thus the payback period for converting from coal to wood boilers is always negative

After eliminating the boilers listed above, there were 12,151 boilers remaining that were sorted based on payback periods. Boilers with invalid city listings were eliminated (9 boilers) for the sort by location. There were also a number of boilers were it appears that the boiler capacity was incorrectly entered so the boiler would appear to be significantly smaller than expected. In these cases the payback years calculated were exceedingly high, and consequently, there may be some potentially viable projects that appear unviable. It is also possible that an individual boiler may not appear to be viable for conversion by itself. However, it may be one of several boilers within close proximity to each other (possibly even within one facility) that, if combined into one biomass boiler system, would be a viable project. <u>This reinforces the idea that the simple payback calculations, based on the assumptions here, should not be used to identify or eliminate any particular facility. The characteristics of each potential project need to be examined much more closely than the broad strokes used in this study before viability can be determined.</u>

Table 40 presents the number of boilers with payback periods within selected ranges for the circumstances when boiler replacement is pending or planned for (replacing boiler anyway), and also when it is not (boiler does not need to be replaced). The payback period for the scenario where a boiler needs to be replaced is calculated based on the time it would take for annual fuel saving to pay for the extra expense of buying a new wood boiler rather than buying a new gas boiler. For the scenario where a boiler doesn't need to be replaced, the payback period is time it takes for annual fuel saving to pay for a new wood boiler.

Table 40. All Boilers Sorted Into Payback Periods

PAYBACK SCENARIOS -- ALL BOILERS				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	84		< 5 years	15
5 to <10 years	158		5 to <10 years	88
10 to <15 years	157		10 to <15 years	160
15 to 20 years	145		15 to 20 years	191
> 20 years	11,407		> 20 years	11,697

Tables 41 through 44 present the number of boilers in selected payback ranges sorted by existing fuel source. Tables 45 through 49 present the number of boilers in selected payback ranges sorted by size. Tables 50 through 78 present the number of boilers in selected payback ranges sorted by county. Tables 79 through 82 present payback periods for example boilers within selected size ranges, utilization rates, and existing fuel types.

Boilers Sorted Into Payback Periods by Existing Fuel Type

Table 41. Electric Boilers Sorted Into Payback Periods

ELECTRIC BOILERS				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	1		< 5 years	1
5 to <10 years	1		5 to <10 years	0
10 to 20 years	14		10 to 20 years	9
> 20 years	340		> 20 years	346

Table 42. Gas Boilers Sorted Into Payback Periods

GAS BOILERS				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	79		< 5 years	13
5 to <10 years	150		5 to <10 years	85
10 to 20 years	456		10 to 20 years	294
> 20 years	10,964		> 20 years	11,257

Table 43. Oil Boilers Sorted Into Payback Periods

OIL BOILERS				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	3		< 5 years	1
5 to <10 years	3		5 to <10 years	2
10 to 20 years	24		10 to 20 years	18
> 20 years	38		> 20 years	57

Table 44. Propane Boilers Sorted Into Payback Periods

PROPANE BOILERS				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	1		< 5 years	0
5 to <10 years	2		5 to <10 years	1
10 to 20 years	7		10 to 20 years	5
> 20 years	68		> 20 years	72

Boilers Sorted Into Payback Periods by Size Ranges

Table 45. 50+ MMBtu/hr Boilers Sorted Into Payback Periods

BOILERS 50,000,000+ BTU/hr				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	51		< 5 years	11
5 to <10 years	0		5 to <10 years	40
10 to 20 years	0		10 to 20 years	0
> 20 years	0		> 20 years	0

Table 46. 10 to <50 MMBtu/hr Boilers Sorted Into Payback Periods

BOILERS 10,000,000 to 49,999,999 BTU/hr				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	33		< 5 years	4
5 to <10 years	147		5 to <10 years	48
10 to 20 years	168		10 to 20 years	232
> 20 years	1		> 20 years	65

Table 47. 5 to <10 MMBtu/hr Boilers Sorted Into Payback Periods

BOILERS 5,000,000 to 9,999,999 BTU/hr				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	9		5 to <10 years	0
10 to 20 years	247		10 to 20 years	53
> 20 years	271		> 20 years	474

Table 48. 1 to <5 MMBtu/hr Boilers Sorted Into Payback Periods

BOILERS 1,000,000 to 4,999,999 BTU/hr				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	80		10 to 20 years	55
> 20 years	3,752		> 20 years	3,777

Table 49. 0.5 to <1 MMBtu/hr Boilers Sorted Into Payback Periods

BOILERS 500,000 to 999,999 BTU/hr				
payback if boiler replacement required	**number of boilers**		**payback if replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	5		10 to 20 years	2
> 20 years	7,387		> 20 years	7,390

Boilers Sorted Into Payback Periods by County

Table 50. Boilers In Beaver County Sorted Into Payback Periods

BEAVER COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	3		5 to <10 years	0
10 to 20 years	4		10 to 20 years	6
> 20 years	49		> 20 years	50

Table 51. Boilers In Box Elder County Sorted Into Payback Periods

BOX ELDER COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	2		< 5 years	0
5 to <10 years	10		5 to <10 years	2
10 to 20 years	44		10 to 20 years	22
> 20 years	188		> 20 years	219

Table 52. Boilers In Cache County Sorted Into Payback Periods

CACHE COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	4		< 5 years	4
5 to <10 years	15		5 to <10 years	2
10 to 20 years	19		10 to 20 years	22
> 20 years	362		> 20 years	372

Table 53. Boilers In Carbon County Sorted Into Payback Periods

CARBON COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	2		< 5 years	0
5 to <10 years	1		5 to <10 years	2
10 to 20 years	12		10 to 20 years	9
> 20 years	223		> 20 years	227

Table 54. Boilers In Daggett County Sorted Into Payback Periods

DAGGETT COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	10		> 20 years	10

Table 55. Boilers In Davis County Sorted Into Payback Periods

DAVIS COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	7		< 5 years	0
5 to <10 years	15		5 to <10 years	12
10 to 20 years	43		10 to 20 years	26
> 20 years	757		> 20 years	784

Table 56. Boilers In Duchesne County Sorted Into Payback Periods

DUCHESNE COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	3		5 to <10 years	0
10 to 20 years	2		10 to 20 years	3
> 20 years	841		> 20 years	843

Table 57. Boilers In Emery County Sorted Into Payback Periods

EMERY COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	1		10 to 20 years	0
> 20 years	61		> 20 years	62

Table 58. Boilers In Garfield County Sorted Into Payback Periods

GARFIELD COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	3		10 to 20 years	2
> 20 years	47		> 20 years	48

Table 59. Boilers In Grand County Sorted Into Payback Periods

GRAND COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	3		< 5 years	0
5 to <10 years	0		5 to <10 years	3
10 to 20 years	0		10 to 20 years	0
> 20 years	99		> 20 years	99

Table 60. Boilers In Iron County Sorted Into Payback Periods

IRON COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	3		< 5 years	1
5 to <10 years	5		5 to <10 years	5
10 to 20 years	5		10 to 20 years	5
> 20 years	162		> 20 years	164

Table 61. Boilers In Juab County Sorted Into Payback Periods

JUAB COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	1		< 5 years	0
5 to <10 years	2		5 to <10 years	1
10 to 20 years	2		10 to 20 years	4
> 20 years	41		> 20 years	41

Table 62. Boilers In Kane County Sorted Into Payback Periods

KANE COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	31		> 20 years	31

Table 63. Boilers In Millard County Sorted Into Payback Periods

MILLARD COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	1		< 5 years	0
5 to <10 years	1		5 to <10 years	1
10 to 20 years	5		10 to 20 years	5
> 20 years	92		> 20 years	93

Table 64. Boilers In Morgan County Sorted Into Payback Periods

MORGAN COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	2		10 to 20 years	0
> 20 years	18		> 20 years	20

Table 65. Boilers In Piute County Sorted Into Payback Periods

PIUTE COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	6		> 20 years	6

Table 66. Boilers In Rich County Sorted Into Payback Periods

RICH COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	23		> 20 years	23

Table 67. Boilers In Salt Lake County Sorted Into Payback Periods

SALT LAKE COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	37		< 5 years	4
5 to <10 years	56		5 to <10 years	38
10 to 20 years	213		10 to 20 years	145
> 20 years	4,472		> 20 years	4,591

Table 68. Boilers In San Juan County Sorted Into Payback Periods

SAN JUAN COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	57		> 20 years	57

Table 69. Boilers In Sanpete County Sorted Into Payback Periods

SANPETE COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	3		< 5 years	0
5 to <10 years	2		5 to <10 years	4
10 to 20 years	7		10 to 20 years	2
> 20 years	120		> 20 years	126

Table 70. Boilers In Sevier County Sorted Into Payback Periods

SEVIER COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	87		> 20 years	87

Table 71. Boilers In Summit County Sorted Into Payback Periods

SUMMITT COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	2		5 to <10 years	0
10 to 20 years	12		10 to 20 years	6
> 20 years	530		> 20 years	538

Table 72. Boilers In Tooele County Sorted Into Payback Periods

TOOELE COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	1		< 5 years	0
5 to <10 years	0		5 to <10 years	1
10 to 20 years	16		10 to 20 years	11
> 20 years	170		> 20 years	175

Table 73. Boilers In Uintah County Sorted Into Payback Periods

UINTAH COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	1		< 5 years	1
5 to <10 years	1		5 to <10 years	0
10 to 20 years	5		10 to 20 years	3
> 20 years	231		> 20 years	234

Table 74. Boilers In Utah County Sorted Into Payback Periods

UTAH COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	10		< 5 years	3
5 to <10 years	15		5 to <10 years	8
10 to 20 years	51		10 to 20 years	38
> 20 years	1,346		> 20 years	1,373

Table 75. Boilers In Wasatch County Sorted Into Payback Periods

WASATCH COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	3		10 to 20 years	3
> 20 years	95		> 20 years	95

Table 76. Boilers In Washington County Sorted Into Payback Periods

WASHINGTON COUNTY				
payback if boiler replacement required	number of boilers		payback if boiler replacement not necessary	number of boilers
< 5 years	0		< 5 years	0
5 to <10 years	5		5 to <10 years	0
10 to 20 years	9		10 to 20 years	8
> 20 years	410		> 20 years	416

Table 77. Boilers In Wayne County Sorted Into Payback Periods

WAYNE COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	12		> 20 years	12

Table 78. Boilers In Weber County Sorted Into Payback Periods

WEBER COUNTY				
payback if boiler replacement required	**number of boilers**		**payback if boiler replacement not necessary**	**number of boilers**
< 5 years	9		< 5 years	2
5 to <10 years	21		5 to <10 years	9
10 to 20 years	42		10 to 20 years	31
> 20 years	867		> 20 years	897

Example Paybacks by Fuel Source

Table 79. Example Paybacks To Convert Boilers Of Varying Sizes And Utilization Rates To Biomass If They Currently Use Gas As A Fuel Source

EXISTING FUEL SOURCE = GAS			
Boiler Size (BTU/hr)	**Boiler Utilization**	**payback if boiler replacement required (years)**	**payback if boiler replacement not necessary (years)**
1,000,000	Low	201	228
1,000,000	Medium	75	85
1,000,000	High	40	46
2,500,000	Low	93	117
2,500,000	Medium	35	44
2,500,000	High	19	23
5,000,000	Low	55	76
5,000,000	Medium	21	29
5,000,000	High	11	15
10,000,000	Low	37	57
10,000,000	Medium	14	21
10,000,000	High	7	11
15,000,000	Low	30	48
15,000,000	Medium	11	18
15,000,000	High	6	10
20,000,000	Low	22	35
20,000,000	Medium	8	13
20,000,000	High	4	7
25,000,000	Low	19	31
25,000,000	Medium	7	12
25,000,000	High	4	6
50,000,000	Low	12	20
50,000,000	Medium	4	8
50,000,000	High	2	4
75,000,000	Low	11	19
75,000,000	Medium	4	7
75,000,000	High	2	4

Table 80. Example Paybacks To Convert Boilers Of Varying Sizes And Utilization Rates To Biomass If They Currently Use Electricity As A Fuel Source

EXISTING FUEL SOURCE = ELECTRICITY			
Boiler Size (BTU/hr)	**Boiler Utilization**	**payback if boiler replacement required (years)**	**payback if boiler replacement not necessary (years)**
1,000,000	Low	93	105
1,000,000	Medium	35	39
1,000,000	High	19	21
2,500,000	Low	43	54
2,500,000	Medium	16	20
2,500,000	High	9	11
5,000,000	Low	26	35
5,000,000	Medium	10	13
5,000,000	High	5	7
10,000,000	Low	17	26
10,000,000	Medium	6	10
10,000,000	High	3	5
15,000,000	Low	14	22
15,000,000	Medium	5	8
15,000,000	High	3	4
20,000,000	Low	10	16
20,000,000	Medium	4	6
20,000,000	High	2	3
25,000,000	Low	9	14
25,000,000	Medium	3	5
25,000,000	High	2	3
50,000,000	Low	5	9
50,000,000	Medium	2	4
50,000,000	High	1	2
75,000,000	Low	5	9
75,000,000	Medium	2	3
75,000,000	High	1	2

Table 81. Example Paybacks To Convert Boilers Of Varying Sizes And Utilization Rates To Biomass If They Currently Use Oil As A Fuel Source

EXISTING FUEL SOURCE = OIL			
Boiler Size (BTU/hr)	**Boiler Utilization**	**payback if boiler replacement required (years))**	**payback if boiler replacement not necessary (years)**
1,000,000	Low	97	109
1,000,000	Medium	36	41
1,000,000	High	19	22
2,500,000	Low	45	56
2,500,000	Medium	17	21
2,500,000	High	9	11
5,000,000	Low	27	37
5,000,000	Medium	10	14
5,000,000	High	5	7
10,000,000	Low	18	27
10,000,000	Medium	7	10
10,000,000	High	4	5
15,000,000	Low	14	23
15,000,000	Medium	5	9
15,000,000	High	3	5
20,000,000	Low	11	17
20,000,000	Medium	4	6
20,000,000	High	2	3
25,000,000	Low	9	15
25,000,000	Medium	3	6
25,000,000	High	2	3
50,000,000	Low	6	10
50,000,000	Medium	2	4
50,000,000	High	1	2
75,000,000	Low	5	9
75,000,000	Medium	2	3
75,000,000	High	1	2

Table 82. Example Paybacks To Convert Boilers Of Varying Sizes And Utilization Rates To Biomass If They Currently Use Propane As A Fuel Source

EXISTING FUEL SOURCE = PROPANE			
Boiler Size (BTU/hr)	**Boiler Utilization**	**payback if boiler replacement required (years)**	**payback if boiler replacement not necessary (years)**
1,000,000	Low	91	103
1,000,000	Medium	34	39
1,000,000	High	18	21
2,500,000	Low	42	53
2,500,000	Medium	16	20
2,500,000	High	8	11
5,000,000	Low	25	35
5,000,000	Medium	9	13
5,000,000	High	5	7
10,000,000	Low	17	26
10,000,000	Medium	6	10
10,000,000	High	3	5
15,000,000	Low	13	22
15,000,000	Medium	5	8
15,000,000	High	3	4
20,000,000	Low	10	16
20,000,000	Medium	4	6
20,000,000	High	2	3
25,000,000	Low	8	14
25,000,000	Medium	3	5
25,000,000	High	2	3
50,000,000	Low	5	9
50,000,000	Medium	2	3
50,000,000	High	1	2
75,000,000	Low	5	9
75,000,000	Medium	2	3
75,000,000	High	1	2

CONTACTS

Laura L. Lowe
Department of Natural Resources
Division of Forestry, Fire & State Lands
1954 W North Temple, Suite 3520
PO Box 145703
Salt Lake City, UT 84114-5703
www.ffsl.utah.gov

For further information about the Fuels for Schools and Beyond program please visit their website: www.fuelsforschools.org

Or contact the Forest Service Fuels for Schools Economic Action Program Coordinator:
Dave Atkins
USDA Forest Service, State & Private Forestry
200 E Broadway, PO Box 7669
Missoula, MT 59807
(406) 329-3134
Datkins@fs.fed.us

ACKNOWLEDGEMENTS

This report was patterned after the Biomass Boiler Market Assessment (2004) and Update (2006) for Montana authored by CTA Architects and Engineers, Christopher Allen + Associates, Montana Community Development Corp., and Geodata Services, Inc. They developed the formulas and many of the assumptions adopted in this report. The strategic recommendations and discussion of opportunities and barriers primarily came from their assessment for Montana, but were applicable to all the region involved in the Fuels for Schools and Beyond program and thus were included here. Utah appreciates their efforts and their assistance as well as the work that went into the other sources of data referenced.

Thanks are also in order for each of the state coordinators in the region who have passed on their wisdom, particularly Dave Atkins, the regional program coordinator. Their guidance and support has been invaluable.

Funding for this report came from a Fuels for Schools grant to the State Forester with matching funding from the former Utah Energy Office; a Western Governors' Association grant; and US Forest Service Economic Action grant funding. There were also personnel from the former Utah Energy Office who did some preliminary research and provided advice. Thanks to them.

REFERENCES

[1] IEA Bioenergy "Economic Instruments for Overcoming Barriers for Bioenergy." http://www.aboutbioenergy.info/economy_economic.html (Accessed April 14, 2006)
[2] "Four Pellet Plants Planned for British Columbia" *Prince George Citizen*, June 1, 2006.
[3] "Energy Companies Count Their Chips Among the Debris," *Houston Chronicle*, March 20, 2006.
[4] Mater, Jean 1997. *Reinventing the Forest Industry*. Green Tree Press: Wilsonville, OR. p.183
[5] American Forest and Paper Association, 200?. *U.S. Forest Facts and Figures, 2001*. p. 6 http://www.afandpa.org/Content/NavigationMenu/Forestry/Forestry_Facts_and_Figures/Forestry_Facts_and_Figures.htm (Accessed Aug 18, 2006)
[6] O'Brien, Renee. 1999. "Comprehensive Inventory of Utah's Forest Resources, 1993." USDA Forest Service, Rocky Mountain Research Station, Resource Bulletin, RMRS-RB-1. March 1999.

[7] O'Brien, Renee. 1999. "Comprehensive Inventory of Utah's Forest Resources, 1993." USDA Forest Service, Rocky Mountain Research Station, Resource Bulletin, RMRS-RB-1. March 1999.
[8] US Department of Energy, Energy Efficiency and Renewable Energy Biomass Program, Feedstock Composition Glossary http://www1.eere.energy.gov/biomass/printable_versions/feedstock_glossary.html (Accessed Aug 11, 2006)
[9] Oak Ridge National Laboratory, 2005. *Biomass as Feedstock for a BioEnergy and BioProducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*. http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf
[10] Walsh, M. et al. 2000. "Biomass Feedstock Availability in the United States: 1999 State Level Analysis, Oak Ridge: Oak Ridge National Laboratory, April 1999, Updated January 2000. http://bioenergy.ornl.gov (Accessed April11, 2006).
[11] Western Governors' Association. 2006. *Clean and Diversified Energy Initiative, Biomass Task Force Report Supply Addendum*, January 2006. http://www.westgov.org/wga/initiatives/cdeac/Biomass-supply.pdf (Accessed Feb 10, 2006)
[12] US Forest Service, Forest Inventory and Analysis Data Center, http://www.ncrs2.fs.fed.us/4801/FIADB/index.htm (Accessed April 17, 2006)
[13] USDA Forest Service. 2005. "A Strategic Assessment of Forest Biomass and Fuel Reduction Treatments in Western States," General Technical Report RMRS-GTR-149. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station, 17 p. http://www.fs.fed.us/research/infocenter.html.
[14] http://extension.usu.edu/forestry/Business/WoodDirectory.htm (Accessed Dec 13, 2006).
[15] Morgan, Todd et al., 2006. "The Four Corners Timber Harvest and Forest Products Industry, 2002." USDA Forest Service, Rocky Mountain Research Station, Resource Bulletin, RMRS-RB-7, May 2006.
[16] CTA Architects and Engineers et al. 2006. Montana Biomass Boiler Market Assessment. Draft Report May 18, 2006.
[17] Utah Legislature, http://www.le.state.ut.us/~2006/bills/hbillenr/hb0080.htm
[18] Wood, John H., et, al. 2004. "Long-Term World Oil Supply Scenarios," posted on the Energy Information Administration, U.S. Department of Energy website http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2004/worldoilsupply/oilsupply04.html (Accessed Aug 21, 2006)
[19] CTA Architects and Engineers et al. 2006. Montana Biomass Boiler Market Assessment. Draft Report May 18, 2006.
[20] Perlich, Pam. 2003. Bureau of Economic and Business Research, University of Utah, "The Coming Boom in Utah's School Age Population" Presentation for Wasatch Front Economic Forum, January 9, 2003, http://governor.utah.gov.dea/Presentations/WFEFSchool.pdf (accessed June 7, 2006).
[21] Governor's Office of Planning and Budget. 2005. Baseline Subcounty Projections. *Utah Data Guide* Summer/Fall 2005. http://governor.utah.gov/dea/DataGuide/05udg09.pdf (Accessed June 7, 2006).
[22] http://www.districtenergy.com/AboutUs/ (Accessed Aug 6, 2006).
[23] http://www.districtenergy.com/CurrentActivities/chp.html (Accessed Aug 7, 2006).
[24] http://www.eea-inc.com/chpdata/States/UT.html (Accessed Aug 5, 2006)

[25]Utah Geological Survey, State Energy Program
http://geology.utah.gov/sep/energydata/statistics/electricity5.0/T5.12%20&%20F5.2.xls (Accessed Aug 4, 2006).
[26] http://www.irs.gov/pub/irs-pdf/f8835.pdf (Accessed January 11, 2007).
[27]Johnson, Tom. 2006. Southern Company Services. "Biomass Co-firing Experience in Utility Pulverized Coal Power Plants." Presentation at Smallwood 2006, Richmond, VA May 16, 2006.
http://www.forestprod.org/smallwood06johnson.pdf (Accessed Aug 3, 2006).
[28] Stafford Jerry, 2005. "Santee Cooper's Green Energy Development," *Forest Landowner*, Nov/Dec 2005.
[29] USDA Forest Service, State & Private Forestry. 2005. "Rocky Mtn. Region 1st to Purchase Forest Biomass-based Renewable Energy Certificates." http://www.wflccenter.org/success_stories/45.php (accessed Feb 6, 2006)
[30] U.S. Department of Energy, Energy Efficiency and Renewable Energy
http://www1.eere.energy.gov/biomass/printable_versions/economic_growth.html (Accessed Aug 11, 2006)
[31] "Department of Defense Seeks to Explore the Use of Biofuels," *Biomass Research &Development Initiative Newsletter*, December 2006. http://www.brdisolutions.com/default.aspx (Accessed Jan 3, 2007)
[32] 109th Congress, 2d Session, S 3719 and HR 5904. http://thomas.loc.gov (accessed July 31, 2006)
[33] USDA Forest Service, Inter-Deputy Team Charter, Woody Biomass Utilization Team, August 17, 2004.
[34] "Energy Policy Ambitious," *Deseret Morning News*, April 27, 2006.
[35] Energy Policy for the State of Utah, http://energy.utah.gov/energy/policy.html (Accessed April 27, 2006)
[36] Utah Geological Survey, State Energy Program.
http://geology.utah.gov/sep/incentives/rincentives.htm#retaxcred. (Accessed Aug 3, 2006) For a database of all incentives in the nation visit http://www.dsireusa.org.
[37] http://www.pacificorp.com/File/File65030.pdf (Accessed Aug 5, 2006)
[38] http://www.fuelsforschools.org/fundamentals.html (Accessed Aug 5, 2006)
[39] TSS Consultants, 2002. Preliminary Business plan / Financial Projections for a Biomass Power Plant in Prineville, Oregon. Rancho Cordova, CA.
[40] Bergman, Richard and John Zerbe. 2001. Primer on Wood Biomass for Energy. USDA Forest Service, Technology Marketing Unit, Forest Products Laboratory.
[41] Biomass Research and Development Board. 2001. Fostering the Bioeconomic Revolution in Biobased Products and Bioenergy. http://www.newuses.org/pdf/strategicplan.pdf (Accessed Aug 23, 2006)
[42] Sandberg, David V.; Ottmar, Roger D.; Peterson, Janice L.; Core, John. 2002. Wildland fire on ecosystems: effects of fire on air. Gen. Tech. Rep. RMRS-GTR-42-vol. 5. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 79 p. (Quote on p.20)
[43] Gropp, Ron and Dunford, Tracy. 2005. Utah Division of Forestry, Fire & State Lands, Cooperative Forestry and Fire Programs, State Fiscal Year 2005 Annual Report.
[44] Air Quality Issues Associated with Wood Boilers. http://www.fuelsforschools.org/pdf/AirQualityInfo_FFS.pdf (Accessed Aug 22, 2006)
[45] Pellet Fuels Institute, http://www.pelletheat.org/2/index/index.html (Accessed Aug 5, 2006)
[46] "New Air Standards Ready for Inversion Season" *Deseret Morning News*, Nov 1, 2006, and "Red-Green Air Quality Alert Kicks off with Stricter Standards," *The Salt Lake Tribune*, Nov 1, 2006.
[47] http://www.airquality.utah.gov/images/Maps/NONATTAINMENT_MAP.pdf (Accessed Aug 3, 2006)
[48] http://www.airquality.utah.gov/Public-Interest/Current-Issues/Regionalhazesip/index.htm (Accessed Aug 3, 2006)
[49] http://www.rules.utah.gov/publicat/code/r307/r307-204.htm (Accessed Aug 3, 2006)
[50] Utah Geological Survey, State Energy Program http://geology.utah.gov/sep/energydata/renewenergydata.htm (Accessed Aug 7, 2006)
[51] Energy Information Administration, "Renewable Energy Annual, 2004."
http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea_sum.html (Accessed Nov 2, 2006)
[52] http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm (Accessed Aug 5, 2006)
[53] Energy Services Coalition, http://www.energyservicescoalition.org/resources/whatis.htm) (Accessed Aug 8, 2006)
[54] Govett, Robert, et al. 2004. "Wood Fueled Boiler Financial Feasibility" University of Wisconsin-Stevens Point For spreadsheet program and manual see http://forest.wisc.edu/fe_publications.htm
[55] U.S. Forest Service, 2004. Forest Products Laboratory, State & Private Forestry Technology Marketing Unit "Wood Biomass for Energy" *TechLine*, updated April 2004.